From Change to Renewal: Educational Technology Foundations of Electronic Learning Environments

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Educational technology foundations of electronic learning Environments

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1. Introduction

In this speech I will take you along on the exciting journey that my colleagues[1] and I have been making the past years in the area of educational renewal through electronic learning environments. We are still fully involved in this area and the end is not anywhere near.

The journey begins with the familiar observation that the social demand for high-qualitative, well-educated 'knowledge workers' is increasing rapidly. The requirement for people with higher professional education and university education is consequentially expected to increase by 15 to 20 percent in the coming years. (ROA, 1998).[2]

Knowledge is also no longer something that you acquire once in your life. The tendency, increasingly, is that people are busy their whole lives with the acquisition of new knowledge and the development of permanent competencies. Individualisation and employability also play an increasingly larger role in society. As a result, people are more and more often bearing the responsibility for learning and for their ability to be used in the labour market. In addition, new developments in Information and Communication Technology (ICT) are making it possible for people throughout the world at any time to communicate with others and to acquire tailor-made information. People also work increasingly with computers.

These developments raise assorted questions large and small, such as: which knowledge and competencies will be under discussion in the initial phase of higher education, and which will come after that? How do you teach people to regularly and efficiently acquire new knowledge and competencies themselves? How do you make manifest, in a reliable and valid way, the competencies and knowledge that someone has? How do you accredit competencies? Which educational models can adequately fulfil the current requirements and possibilities? Where is face-to-face instruction advisable, where distance education, where a mixed form and where other approaches such as on-the-job help and coaching? When do you—and do not you—use ICT? How do you use ICT adequately in education? Fascinating questions, with which many politicians, managers, educational scientists, directors of education, teachers and human-resource managers are occupied, or, in any case, should be occupied.

The key question is what all these developments mean for the social function that existing educational systems fulfil. In their present form do these systems still satisfy a need? Can they be adapted to accommodate the changes, or must they be completely renewed, to the extent that the mission and organisational structure change fundamentally? My assumption is that, given current developments, institutes for higher education in the future must occupy themselves primarily with offering electronic learning environments, in initial as well as post-initial education. As I will demonstrate to you, this does not involve the somewhat 'dead' digital learning environments that we currently know. What I mean are advanced, flexible, social systems, supported with ICT,

that are many times richer than the usual offering put forth by institutions of face-to-face or distance education.
The realisation of this course cannot be achieved with smaller or larger adaptations to the institution's design or infrastructure. It will certainly not work if the innovation is restricted to making available a large number of computers and other infrastructure, as often happens these days.[3] Continually shouting that there is a shortage of teachers will also be unsuccessful. The question must also be raised as to whether teachers are currently being used to their full advantage. Given modern developments, some tasks can easily be dealt with in another way, possibly even automated. Other tasks must be strengthened in the context of electronic learning environments. In short, we must thoroughly consider the interaction between educational renewal and the mission, organisation, staffing and infrastructure of organisations and institutions. Real renewal, then. Only then people can gather information and develop competencies their entire lives and as desired in an effective, efficient and attractive manner.

Electronic learning environments are not yet public property, but in many places a start has been made in digitising education and training. An example can be found in the area of industrial training. For instance, Shell announced in a press release (*Computable,* 1-9-2000, p. 1) that it was making a definitive switch to a digital learning environment for the internal training of its 10,000 college graduates. This company thinks that placing a teacher before a class no longer fits with today's needs. There are diverse reasons: it is increasingly difficult to give employees long periods of time off to attend a course elsewhere. Shell also considers the reach of classical education too limited, among other reasons because their top experts cannot be sufficiently involved with. Travel costs are another factor.
In higher professional education, a beginning has been made in the introduction of dual trajectories, in which the ambition is to integrate work and learning to a great extent. Because students are present at school less often, a real problem has arisen involving communication and the exchange of information between students, teachers, institutes and work practicum. These problems can only be conclusively resolved by instituting electronic learning environments. Another example is the recent development of the Open University of the Netherlands and the planned formation of a Digital University.[4] The intention is to develop digital education in cooperation with universities and colleges of higher professional education.

In this speech you and I will search for the direction desired for digitalisation of education and training. To begin, I will examine what a learning environment is. Next, I will answer the question of what innovation potential ICT offers for the establishment of learning environments. This is a very promising area, but one of the greatest challenges is how to make these possibilities truly operational. Renewal frequently gets bogged down in ambition. This is why I and my colleagues in the educational technology development programme continue to systematically explore to what extent we can realise the ambitions and to what extent we have to adjust, by making the concepts operational, by orchestrating them and by testing them in practice.
In discussing these subjects, I would, by the way, like to give as much attention as possible to the principles and foundations underlying them, and I will limit or completely ignore the transitory aspects of these subjects. I think that in education quite a lot of energy is wasted on chasing solutions that have everything to do with chance technical possibilities, and nothing to do with fundamental renewal. I have been involved in the world of electronic learning environments for more than fifteen years now, and I have seen all manner of things come and go. Just think about the hype surrounding multimedia, intelligent tutor systems, hypermedia, bulletin boards, CD-I, CD-ROM, and now, Internet. When such a technique disappears, and is replaced by advanced possibilities, then begin the discussions about the value and use, often once more from the top. Foundations and generic principles are, therefore, important in order to see and realise real development and improvement, because it is true that the techniques of

today and tomorrow offer unimaginably more possibilities for innovation than those of yesterday, and that will continue for quite some time.

I will end this speech with my vision of the desired direction for further development of advanced learning environments. As I have already said, we have already travelled a great distance, but the end of our journey is still far from over.

2. Learning environments

2.1. The concept of the learning environment

The term learning environment is currently used a lot, but is seldom defined. The term is ascribed all kinds of meanings, completely dependent on the question, which part of the elephant is being touched and by whom.
For some the concept is used to indicate the physical space in which learning processes can occur, such as a classroom, a laboratory or a self-instructional area (Tessmer & Harris, 1992). Others see it primarily in the significance of specific educational software (Papert, 1980; Boyle, 1997; Wiencke & Roblyer, 2000), or as the whole of educational content, the instructional method, the sequence of learning activities and the social aspects of learning (Collins, Brown & Holum, 1991; Grabinger, 1996; Pulkkinen, 1999).[5]
Salomon (1996) considers a learning environment as the whole physical setting, the collection of accepted behaviours, collective expectations and specific tasks, all grouped around specific educational content and defined objectives. In addition, in his vision one person, the teacher, has responsibility for the whole.[6]

In my work I have interpreted the concept of learning environment rather broadly, but formally, as a system, in particular, a social system. I will elaborate on this and then define learning environments from that perspective.
A system is a collection of elements that, in its entirety, has characteristics that cannot be converted into the compositional elements. The systems theory offers a general framework in which to describe and understand structures and processes, for example, those of learning environments. It is essential to state that learning environments are social systems. These can better be described with the modern soft-system approach than with the classic hard-system approach (Checkland, 1999). ‘Human Systems are Different’ states Vickers (1983) in this context. The original system approach is much too mechanistic to serve as a model for social systems. It does not take into account, for example, typical human aspects such as the purposeful nature of dealing with humans, the dialogue and reason, culture, developmental aspects, change and individual differences. People’s behaviour in social systems is not explicable using deterministic rules. Perceptions of the learning environment and people’s choices can always play a role in explaining their behaviour (see, for example, Thorpe, 1974; Vosniadou, 1996; Elen & Lowyck, 1998).
I consider a learning environment more broadly, in reference to the limits of the system. The learning environment includes all objects, contexts and behaviours of the actors who play a role in the development, execution and evaluation of the learning environment. I also make the assumption that the processes in these phases still exhibit, or should exhibit, strong coherence (Winn & Snyder, 1996). In this, some meanings of the concept nearly correspond to the concept of the educational environment or educational system. Yet I prefer the term learning environment, because learning is made explicitly central and because the term educational system has undesirable connotations of familiar, permanent educational-organisational structures.

2.2. Learning environment as a soft system

Social systems in the soft-systems theory are considered as a system of coherent, purposeful human activities[7]. Characteristic of social systems is that they are intellectual constructs, the result of 'Weltanschauungen', that can be different every time. They are not descriptions, but rather perceptions, of reality. This means, for example, that a single correct perception of a social system does not exist, and that interpretations of the system can differ per person. 'Where's the orchestra?' muses Weick (1979, p. 141) in order to understand human organisations. His answer is, 'In the head of the musicians'. The musicians have a commonly agreed perception of the goals, tasks and organisation. In an extension of this, Altman (1988, p. 268) states that there are no exceptional actors in a social system, just connections between the actors. He calls these 'acting relationships'. The activities of a person can only be understood in relation to the activities of other people, and in relation to the circumstances in which the actors find themselves.[8]

Soft systems cannot be validated like hard systems. In other words, there are no valid or invalid learning environments. It is true that one is more defensible than the other, and it is possible to work out whether the description is sufficiently complete by comparing it with a formal system model. Checkland sets out the following specific requirements for a soft system, called S.

1. S has a continuing goal, a mission, and no concrete objectives that cannot be achieved.
2. S contains performance measurements through which can be determined how extensive the progress towards the goal is.
3. S contains a decision process in which regulatory measures can be brought into the system. A number of people can play a role in this process.
4. S has components that to a certain extent are also soft systems themselves with the characteristics of S. S can also contain hard subsystems, such as natural systems, designed physical systems and designed abstract systems.
5. S has components that are connected to a certain extent, or that interact and communicate.
6. S exists in a higher-order system or an environment with which it interacts. S is, therefore, always an 'open' system.
7. S has a border in common with the environment (see 6), which is defined as the area in which the decision process (see 3) has the power to set activities in motion.
8. S has sources (objects and people) that can be deployed by the decision process.
9. S has long-term stability and an internal or external mechanism that can repair disruptions to the system as much as possible.

In addition to these specific characteristics of soft systems, there are also a number of general principles that are valid for hard and soft systems, like the principle that a system can be described from three supplementary perspectives (Banathy, 1996a):

- the function and structure of the system. This description defines what the system is.
- the action (dynamic) of the system. This description defines how a system functions.
- the relation and interaction with the system's environment. This description determines why the system is as it is.

Brethower (1999) also describes general principles. Of the seven principles he names, 'energy channeling' and 'subsystem maximization' are the most important. By 'energy channeling' he means that open systems must always set priorities; they cannot always do everything for everybody. The reason for this is that open systems, by definition, have a shortage of resources. The principle 'subsystem maximization' means that the system as a whole functions best when there is sufficient balance in the functioning of *all* the different subsystems. As soon as <u>one</u> of the subsystems achieves maximised performance, the effectiveness of the system as a whole declines, because this

maximised performance always comes at the expense of the other subsystems' performance.
By considering learning environments as a purposeful social system, there arises a certain philosophy of learning environments and their creation.

2.3. Definition

Based on the context above, I use the following provisional and stipulative definition of a learning environment.

A learning environment is a social system focused on the permanent development and certification of human knowledge and competencies in a particular domain.[9]

Some learning environments are more focused on the development and certification of knowledge; others on the development and certification of competencies. We can, therefore, speak respectively of knowledge-focused or competency-focused learning environments. A competency-focused learning environment always contains one or more knowledge-focused learning environment. Van Merriënboer (1999, p. 16) correctly states in this regard: 'The human cognitive architecture is bound to domain-knowledge.'

The concept 'knowledge' is considered broadly here, namely as all automated procedural and consciously declarative knowledge (Anderson, 1993).[10] What is also valid here is that in most domains that are naturally complex, complete knowledge can never be achieved. People can always improve and choose other points of view.
I consider a competency to be the ability to act consciously and responsibly in a specific context.[11] By 'consciously' I mean man's ability to freely choose how to act, and to do so with a certain passion and attitude. The choice is dependent on an assessment of the situation and on specific underlying motives such as interests, values or the need to solve a problem. With 'responsibility' I am referring to people's ability to justify their choices and actions, and explain them to others, without putting it down to circumstances beyond their control or automatic behaviour, but rather to their own, carefully considered values and choices. In using these terms I wish to clarify that I view a competency as the combination of cognitive, conative and affective aspects that collectively determine behaviour in a given situation (see also Barnett, 1996).
The extent of the resulting behaviour's effectiveness and efficiency can always differ and be developed further in perpetuity. Which competencies are involved always depends on the domain and the contexts within that domain. Many classifications have been made in this area (Everwijn, 1997; Simons, 1997). It is wise to note that notions of personality and intelligence also influence competency categories (for example, Gardner, 1989).

Learning environments are defined within a domain, that is to say within a subject matter or field of study, including the competencies, knowledge and contexts at work there. Domains, in turn, can have assorted relationships, and acquired knowledge and competencies frequently transcend a single domain. An important question is how the domains can best be defined, for example in terms of scope, subject matter, contexts and level. Several proposals have been made, but the presentation of this question requires further analysis, research and development.

Which subsystems does a learning environment contain? In an analysis that we did earlier (Koper, 1989a, 1995, 1998) the following components occur:

1. A logically classified collection of tasks or instructions[12] for different people in the learning environment, to make it clear which activities are expected in which roles and at which moment, based on everyone's file.
2. An activity environment that is available per activity or series of activities, which consists of (a) a collection of objects that can be interacted with, (b) people in a particular role who can be communicated and cooperated with, and (c) a context in which the objects and people are organised.
3. Data about objects and people, such as descriptions of goals, metadata and files.

The heart of the matter is that students and staff members in a learning environment are encouraged towards either learning or supporting activities. This encouragement is provided through tasks or instructions. Tasks can be subdivided into subtasks that have a specific sequence or from which people can make a specific selection. Tasks can be bundled, for example, into a course or course programme. Every person in the environment fulfils one or more roles. Tasks, or activities, are arranged according to the different roles in the learning environment. An activity is carried out in an environment or context with objects and people.

In what follows, I will delineate the concept of learning environment further. That is to say, with the help of a number of subjects I will clarify the interpretation of the definition, in particular, by saying what (by a hair) it is not and what (by a hair) it is.

2.4. Further delineation

2.4.1. A learning environment is not a course or course programme

A learning environment has a goal that is pursued but cannot be achieved. Most courses, on the other hand, are over at some point, as are course programmes. Course goals are usually rigidly defined; you either reach the goal or you do not. You do not do the course a second time. Learning environments can, however, contain courses or course programmes. After all, a soft system can contain hard systems as subsystems.
What does this mean? If you use a learning environment that is defined within a particular domain, in principle you can continue returning there your entire life, to further hone your knowledge and competencies in that domain. That can be achieved by following courses in the learning environment. That can be achieved by following actual developments in that field. By actively contributing to the further development of knowledge in that domain through research and development. By changing roles in a learning environment, namely from that of a student to that of someone who supports other people's learning processes. The learning environment, therefore, is never finished; it is supplemented, replenished and changed. A learning environment does have boundaries based on resource limitations, for example, in the level and delineation of the domain. A learning environment is, nevertheless, better and more useful for life-long learning, as far as it encompasses more. This is also different from courses, as we now often know them; these are strictly limited in scope and study load.

2.4.2. In a learning environment, activities rather than objects are central

One consequence of considering learning environments as a social system is that neither the natural nor designed objects in a learning environment are central. Instead the human activity that is focused on these objects is. Objects are made subordinate to the activity. In distance education and in the classic instructional-design approach it happens fairly often that instructional materials and the media, rather than the learning activities, are central. A learning environment, however, is primarily a model of a social reality, an organisation. Activities in a learning environment nearly always take place in a group context, although there do not always have to be direct interactions among all those involved. In the system everyone has his or her own derived activities and objectives. In a learning environment for independent learning it may seem as if the learning environment is individual, but in the development, execution and evaluation a large number of people, such as designers, authors, managers and quality controllers, frequently play a role that forms an integral component of the system. A learning environment can only be considered in its entirety if all these relationships are mapped out. In addition, it must be decided on a case-by-case basis where precisely the division lies with surrounding systems. As described in the formal model, this depends on the positioning and influence of the decision-making process on the system. Student activities are taken as the starting point in designing learning environments. The activities of other people and of the objects are related to this perspective. In addition, the entire life cycle of education, development, execution and evaluation is charted and included in a single decision-making process (cf. Jochems in this collection).

2.4.3. A knowledge-focused learning environment is more than a walking encyclopaedia

You may think that a knowledge-focused learning environment is a kind of knowledge pool that is arranged in some manner and searchable, much like a hypertext system or a library. These components can be part of a knowledge-focused learning environment, but such an environment encompasses more, namely the possibility to add self-knowledge, perspectives, and instructional components. People can exchange and discuss ideas and perspectives with others, form their own opinions and filter the knowledge through their own preferences. In addition, advising and testing can form part of the learning environment. In knowledge-focused learning environments it is not only about declarative knowledge but also about procedural knowledge. Clark (1999) notes in this context that the cognitive system in learning makes no distinction between knowledge and skills, as often happens in curricula that are arranged according to Bloom's (1956) principles. In the learning of both knowledge and skills, both declarative and procedural knowledge are always under discussion.

2.4.4. A competency-focused learning environment is more than a practice environment

A competency-focused learning environment can also not be equated with an advanced practice environment, such as a good simulation program (for example, Gibbons, Fairweather, Anderson & Merrill, 1997; Van de Ven, 1998), or the practical confrontations made by the Open University of the Netherlands.[13] Simulations can be part of a competency-focused learning environment. Central to this competency development is being able to act consciously and responsibly in a specific context. This context can be party simulated, but with the current technical possibilities, the developmental costs of an extensive, realistic simulator with multi-sensory import and export are still so high that it can only be used in exceptional cases. In many cases reality is there for the taking and it is totally unnecessary to simulate this, for example, because failing is not dangerous in most contexts. In addition, contexts age rapidly, and it is necessary for the promotion of the distant transfer of learning that the most varied possible offering of context and problems is available (Butterfield & Nelson, 1989). A competency-focused learning environment, then, will usually not try itself to simulate reality, such as a work environment, unless this is already a 'computer reality', as is the case in more and more professions. The competency-focused learning environment, then, will be primarily focused on the appropriate offering of productive educational tasks that are carried out in a real context, with others, although not mediated. In addition, the progress achieved will be inventoried, knowledge-focused learning environments or parts of them will be made available and contact with people in diverse roles, such as fellow students, tutors and experts, will be facilitated (see also Manderveld & Koper, 1999, 2000).

Accounting for the actions is crucial and plays a role in assessing the competency level reached. After an accounting, it is good to discuss these, and points of improvement can be raised to advance the development process of the competency. In addition, it is important that evaluators who are part of the context in which the actions take place, such as an employer or an expert in a particular field, become involved. An example of this approach can be found in the project VirtueelBedrif [Virtual Company] (for example, Westera & Sloep, 1998), the project IMTO (see, for example, Van Buuren & Giesbertz, 1999).

2.4.5. Not everyone in a learning environment learns the same

People always act based on a social role that is determined by the design of the system. In a learning environment two sorts of roles can be distinguished: student and staff member.[14] These roles can be further differentiated, depending on the instructional scenario. Every learning environment has other roles, depending on the design. Activities in a system are tied to the role a person undertakes in the system. In other words, every role has its own activities. This also means that learning is not only anchored to the context in which the learning takes place, but also to the role that a person takes in the system (cf. Lave & Wenger, 1991). Another factor is that a distinction can be made between the learning environment as it really is and the perception of the learning environment by the users (see, for example, Vermetten, 1999). The precise relationship between role, activity, context, the perception of the learning environment and learning requires much more research and development.

2.4.6. Individual records are a necessary condition

In a learning environment, continuous measurement of progress towards the goal is necessary. Based on this, either the student or a teacher can direct and redirect the system. Yet apart from the assessment method and the organisation of the assessment, which can be based on classic as well as modern testing formats, it is important that this information be kept up to date and managed in a file for each individual. A characteristic and necessary part of a learning environment, then, is also this kind of individualised file. Important questions are: what information should be stored? How should it be stored? How long must it be stored? Who is the owner of what information? How can the information be exchanged? There are many advantages to building accurate files, particularly in large domains. It is best to start from descriptions that are as widely accepted as possible of these domains and of the knowledge and competencies in these domains. In the first place, this facilitates learning, but students also have an instrument on hand with which they can demonstrate to the labour market which qualifications they possess. (Cf. Klarus & Nieskens, 1999; Werkgroep EVC, 2000).

2.4.7. Design of learning environments and instructional design

Using soft-systems theory in the design of learning environments gives another picture than does the use of hard-systems theory, as traditionally happens in the instructional-design approach. I agree with Winn and Snyder (1996) that we can currently speak about the 'era of the design of (learning) environments'. This is in contrast to two previous eras in which instructional design and message design were central. Instructional design is based on the empiric assumption that behaviour is predictable, and that educational design, therefore, can occur in isolation from educational execution. Educational developers in this tradition concentrate primarily on the choice and organisation of the content that students must make their own.
In the era in which message design was central, those influenced by the cognitive tradition shifted attention from educational content to the form in which information was presented. In this tradition it was thought that there was a relationship between the way in which knowledge was offered and the way it was stored in memory (see, for example, Flemming, Levie & Anglin, 1993).

The era in which the design of the learning environments is central involves the design of consistent and well-considered systems of human activity that are focused on reaching objectives (see also, Lee, 1998). The consistency and soundness are based on logic and 'Weltanschauungen' that stems from a system of pedagogical interpretations and convictions, whether or not these are based on empirically validated principles (Koper, 1992). In addition to the fact that the objective is broader than that of, for example, a course or course programme, an important characteristic is that in the design of learning environments more processes are looked at than only the interaction among teachers, students and subject matter. Logistical processes and the administrative side are also designed at the same time, as are the processes that lead to further development and evaluation of the learning environment. Direct or indirect contact with the developers in the leaning environment, therefore, is possible and necessary. Winn and Snyder advocate that such a strict distinction should no longer be made between development, execution and evaluation, but that these have a stronger mutual relationship than in the classic instructional-design approach. In this way, the learning environment can be supplemented and adapted in real time (see also Merrill, 1999).[15] In other words, the system definition is more all-encompassing than in traditional instructional-design approaches (Banathy, 1991, 1996a).

3. Electronic learning environments

3.1. Stimuli for the innovation of learning environments

Assorted stimuli that drive educational innovation can be recognised at the macro, meso and micro levels. Box 1 charts some of the most important stimuli at different levels (see also Dillemans, Lowyck, Van der Perre, Claeys & Elen, 1998).

Box 1 Stimuli for the innovation of learning environments

Macro level
Rapid obsolescence of knowledge, need for life-long learning and for competent, well-educated 'knowledge workers'.

1. Increasing heterogeneity of products and services and increasing interaction among people and systems, among people, and among systems.
2. The internationalisation of large corporations, competition and cooperation on a world scale.
3. The distribution of organisations and the necessity to organise distributed learning processes in these organisations.
4. The use of technology in society and the need to sufficiently familiarise people with this, and where possible to use it as a tool.
5. Questions about cost-effectiveness; who pays what and who determines what.

Meso level
How the infrastructure, buildings, people and work places have to be dealt with.

1. The organisation of educational management and the decision-making processes.
2. The costs, investment in innovation, developmental costs versus operating costs.
3. Who are our partners and who are our competitors?

Micro level
Flexible learning environments (time, place, tempo, sequence, et cetera).

1. Student-centred learning environments.
2. Innovation of the educational models (competency-focused, rich, authentic learning environments, the integration of learning and working).
3. Working with integrated help functions for performance support (see, for example, Milheim, 1997; Van der Klink,1999).
4. Use of ICT.

3.2. The role of information- and communicationtechnology

Especially important for social developments, including educational innovation, are the new possibilities that ICT offers. In broad terms, ICT involves a coherent whole of (a) programmable equipment, whether mobile or not, (b) time- and place- independent communications and (c) time- and place- independent access to relevant, consistent and customised information.
Politicians and planners worldwide recognise that they have only a limited vision of the influence of ICT developments on diverse social sectors such as the economy, the environment, transport, environmental planning and education. This feeling is reinforced because there is somewhat vague talk here and there of a digital revolution taking place. In the Netherlands a study, called Nederland Digitaal (2000), was recently carried out in which for the period ending in 2030 a number of scenarios were worked out describing

the influence of ICT on different sectors. The study stated that the combination of driving and inhibiting forces would determine to what extent ICT would be accepted in society.

The driving force for use of ICT is the need of people and companies for freedom of choice, leisure, and interaction. Information- and communicationtechnologies make it possible to offer very specific, customised services and produces in an efficient, effective and innovative manner. On the one hand, society becomes more heterogeneous because of this. On the other, this again creates an increasing need for interaction to keep social systems sufficiently integrated. This integration is also made possible by ICT, thanks to the increasingly larger network infrastructure that makes interaction and communication among people and systems possible. In other words, ICT increases the heterogeneousness of the social system, but also facilitates the interaction that guarantees integration of the system.
It is also possible to name several inhibiting factors such as high investment- and operating- costs that stem from the fact that ICT products and services quickly become obsolete and must continually be adapted. In addition, such factors as the conservatism of users, protection of privacy, security, the fear of dependence and concern about the reliability of ICT systems come into play. These developments apply not only to the sectors named in the report, but also, of course, to the educational sector. The thinking on educational innovation is currently linked at several points with technological development. This also applies to research and development as well as to actual experience. In my view, a crucial role has also been set aside for educational technology. This can bridge new technological developments, ensure their significant use in practice and work at a sufficient distance on any possible redesign of the educational systems.

In what follows we will examine a few of ICT's possibilities that are connected to educational innovation. This is expressed in terms of a number of central themes: representation, personalisation, integration, cooperation and process control. These subjects also define the demands that can be made on flexible, electronic learning environments.

3.3. Representation

A computer can represent a virtual, simulated[16], multimedia reality. You can see this, for example, if you look at a computer game. The same information can also frequently be represented in a number of different ways. There are, therefore, differences in the representation in terms of the perspective, the degree of precision, the modality used, the specificity and the degree of complexity (Van Someren, Reimann, Boshuizen & De Jong, 1998). It can involve the depiction of a real situation, but also of a newly designed or symbolic reality. Examples of this last are language, algebra and numbers. Vygotsky (1978) views symbolic representations as the interface between knowledge in the world and knowledge in the mind.

Users can form an integral part of the system that is depicted. They are *in* the game and participate in it.[17] User interaction with what is displayed can occur via a standard keyboard and mouse, but also via specific interfaces such as a flight simulator or the interfaces for virtual-reality environments. The representative property of computers has already been used intensively for years in programs that were indicated by the terms 'interactive learning environments', 'computer-assisted instruction' (CAI) or 'educative multimedia' (Alessi & Trollip, 1991; Roblyer & Edwards, 2000). The Suncoo Foundation has, in the past, maintained a catalogue of all the computer-assisted instruction that Dutch organisations have produced for higher education (see also Mirande, Riemersma & Veen, 1997). The Open University of the Netherlands also has a long tradition of designing and developing computer-assisted instruction. More than 120 different programs have been selected or developed and used in education. In recent years, practical confrontations, in particular, have been key. These are programs that, based on the constructivist principles for powerful learning environments (see box 2), offer

authentic work situations and the problems that occur in these. Tutoring is usually built in and based on scaffolding: temporary, gradually decreasing assistance. The development of such programs takes a lot of time and is only rewarding in certain situations, as was demonstrated earlier. Use is also individual. All the ‘people’ with whom the user interacts in the simulations are pre-programmed objects. Teaching materials are also carefully integrated. With the arrival of networks, particularly the Internet, properties were added to the computer that compensate for the deficiencies in computer-assisted instruction. Real people can, therefore, interact, and a broad range of actual teaching materials can be accessed via Internet. Real cooperation is also possible. On the other hand, the power of the representative property is often forgotten during the construction of, for example, web-based education. Many of these web applications are primarily communication channels and are based primarily on the next characteristic to be discussed: the integration of distributed systems.
The representation characteristic gives the designers of a learning environment a lot of freedom. They are barely limited, if at all, by the conditions that the normal, physical environment impose on a design. I have already argued in this context that educational developers should, in the first phases of the design process, design what they feel is the ideal learning environment, in which they make optimal use of available scientific knowledge and creativity (Koper, 1998).[18]

Box 2 Powerful learning environments

The term 'powerful learning environments' (Lodewijks, 1993; Grabinger, 1996; Simons, 1999) is used to indicate learning environments that are based on a constructivist philosophy. This involves comprehensive educational systems that:

- start from *authentic contexts*, that is to say realistic, meaningful, relevant, complex, complete and information-rich contexts in which learning takes place;
- stimulate the *personal development* of students by inviting them to be active and urging them to take responsibility and initiative;
- stimulate a culture of *cooperative learning*. This means that discussion, cooperation and decision-making are felt very strongly about;
- make use of dynamic and productive learning activities that stimulate *higher-order thinking processes* and problem solving, such as analysis, synthesis, experimentation, creativity, and the examination of subjects from different perspectives. The connection of new and existing knowledge also plays a key role here (Hannafin, 1992);
- make use of '*guidance that works*' (Van Merriënboer, 1999, p. 12), such as scaffolding and sequencing of (sub)tasks. Simons (1999) states that a rich learning environment contains a balanced combination of three forms of direction: externally directed, self directed and implicitly directed, as happens in experiential learning;
- make use of *modern assessment formats* (for example, Moerkerke, 1996; Van der Vleuten & Driessen, 2000) such as using real tasks to evaluate students' progress, of both the content and the headway made in 'learning to learn'. The assessment is also intended to develop an understanding of one's own competence.

3.4. Personalisation

Computers offer the possibility of providing the user with relevant and customised information. In education this creates the possibility of personalisation, that is to say, the possibility to adapt objectives, content, sequence, instructional method, navigation and presentation format to a person's preferences or characteristics. Control of these settings can rest with the computer (that is to say: the designer), the teacher or the student. Settings and personal characteristics can be stored in a personal profile. When it comes to learning environments, different terms are used to indicate personalisation, such as 'personalisation', 'individualisation', 'adaptation' and 'open and flexible' (see, for example, Ross & Morrison, 1988; Gavora & Hannafin, 1995). I summarise all these forms with the term 'personalisation'. Two forms of personalisation in the learning environment are discussed in box 3.

Box 3 Adaptive learning environments

The term 'adaptive instruction' is mostly used in situations in which the designer has control over the adaptation process (Park, 1996). The computer can implement this adaptation and the adaptation can occur on two levels:

1. At the macro level, in which the educational goals, the nature of the assessment, the nature and intensity of the guidance and the presentation format can depend on student characteristics and preferences (Glaser, 1977 and Corno & Snow, 1986). Instruction, for example, can be adapted to student characteristics such as learning style, learning conceptions, previous knowledge, motivation or built-in guidance components (Cronbach & Snow, 1977; Martens, 1998).
2. At the micro level, in which students are followed during their education, and the instruction can be adapted according to the wishes and requirements of the moment. Examples are: (self)adaptive testing (Wainer et al, 1990; Rocklin, 1994) and intelligent tutoring systems (Sleeman & Brown, 1982; Shute & Psotka, 1996).

Open and flexible learning environments

Open and flexible learning environments are learning environments in which, according to Hannafin, Land & Oliver (1999), the principle 'the student is central' is fully implemented. In addition to open access and possibly choice of study time, place and tempo, students in an open learning environment can - to a certain extent -define their own educational goals, influence the educational method and content and participate in the evaluation. Open universities, such as those in the UK and the Netherlands, are founded on these principles (Van den Boom & Schlusmans, 1989; De Wolf, 1999, p. 161). In these contexts, technology has always played an important role in achieving this personalisation (see also Bates, 1995; Pulkinnen, 1999).

Again and again, the key question in personalisation is who, and in which circumstances, is responsible for controlling adjustments? The computer, the teacher or the student? This same problem also arises, for example, in the choice of media. The literature records many strategies developed for choosing the right medium (see, for example, Romiszowski, 1988; Koper, 1989b). Another question here, quite apart from the discussion about the influence of media on learning processes, is whether designers should always make the choice, or users themselves be allowed to choose what they want. It is possible for users themselves, with the help of ICT, to choose to receive certain information via the web, on paper or on CD-ROM, for example.

3.5. Integration of distributed subsystems

The property of integration belongs to computers in a network. People can communicate and interact with objects independently of time and place. In addition, the different distributed subsystems are seemingly integrated for users into a single consistent whole. This property is key when terms such as 'tele-learning', 'network-based education', 'telematica', 'educational portal' and 'integrated distributed learning environments (IDLE) (Bates, 1995; Harasim et al, 1995; Berge & Collins, 1995; McGreal, 1998; Collis, 1998; Droste, 1999, 2000) are used in educational contexts. Integration environments involve three functions.

1. Time-independent interaction with objects at a distance. People can, for example, have access to information, such as study guides and schedules, anywhere and anytime, and can interact at a distance with multimedia study materials. Wagner (1999a) calls this the most important characteristic of distributed education.
2. Time- and place-independent communication via e-mail, list servers and discussion groups, and place-independent communication via video- and audio- conferencing.

This function used to be referred to primarily as 'computer conferencing' or 'computer-mediated communication' (for example, Mason & Kaye, 1989). In years past, particularly in distant education institutions, a rich tradition has arisen in the use of these tools. In 1993 Mason even published a collection titled: 'Computer conferencing: the last word'.

3. The linking of existing applications. This primarily involves the integration of computer systems that are important for the organisation and administration of study, for example, for study progress, student files and transactions.This function is currently attracting a lot of attention but, due to the enormous complexity and immaturity of digital learning environments, in particular, is often barely realised these days, if at all.

A number of years ago I led development of the Open University of the Netherlands' Internet services. The development was primarily based on the integration property. After many years of experimenting and evaluating on a smaller scale, we decided the time was right for practical, large-scale implementation. This resulted in, among other things, Studienet (Study web) (see, for example, Koper 1996a, 1996b). This digital learning environment has been operational since 1997 and is attuned for use in open distance education. Some 10,000 students currently use Studienet (Study web) across all Open University of the Netherlands' degree programmes and courses. There are also currently dozens of, mostly new, digital learning environments on the market (see, for example, Droste, 1999, 2000). Such as Blackboard, WebCT, Docent and Lotus Learning Space. These primarily support the integration function. In various places, educators are very busy experimenting with providing education via these kinds of platforms.

Two approaches can be observed in the use of digital learning environments. The first is that educators try to fit these environments as smoothly as possible into education at existing institutions (for example, Collis, 1997, 1998; Schreiber & Berge, 1998; Van Os, 1999). The form the integration takes depends on the kind of institution, face-to-face- or distance- education. In the second approach, not only is the education distributed, but also the educational organisation (see, for example, Lee, 1998). Those responsible strive to provide an integral offering, provided by the different educational institutions working together with employers, libraries, and educational publishers, for example, in order to create extensive and universally accessible learning environments. An example of this is the U.S. Western Governors University (see Wagner, 1999b). This institution arose from an agreement among the governors of fifteen Western American states to cooperatively offer a new form of competency-focused, digital higher education. The planned Digital University in the Netherlands is another example. But just because institutions use integrated environments it still does not say anything about the extent to which they are innovating their education. It can, in all cases, involve substitution, innovation or transformation (see, for example, Jochems, 1999).

3.6. Cooperation

Information- and communication- technology can support cooperation among people working on the same object. This goes a step beyond integration and places special demands on the applications and infrastructure. Just think about collective work on a report in which the computer takes care of version control, routing, text integration, revision and commentary. In this way it is possible to collectively design, solve problems, realise products and, for example, use the same application at a distance. In addition to the tools discussed above, diverse other functions are possible and necessary to support cooperation, for example, common agendas and temporary work environments organised by the individual. This cooperation is often unstructured and self-managed. If clear and set procedures underlie the cooperation, the characteristic 'process management', particularly workflow support, is more appropriate. Many different tools are available to support cooperation. But there are two major problems. First, the applications are often complex to use and second, there are hardly any open standards available in this area, which means applications are isolated and difficult to link with applications from other suppliers. Computer supported collaborative learning (CSCL) is the term used when speaking of using this function in education (see, for example, Koschmann, 1996; Spector, Wasson & Davidsen, 1999). Cooperative learning usually involves stimulating cooperative relationships among small groups of students to accomplish a study task. The assumption is—and this is supported by research—that under certain conditions, cooperative learning provides clear added value compared to individual learning (for an overview, see Johnson & Johnson, 1996). This depends, on the one hand, on the grouping and, on the other, on the kind of task. In literature (for example, Dillenbourg & Schneider, 1995) diverse mechanisms that occur in cooperative learning, but not in individual learning, are held responsible for this. Examples are: conflict, alternative proposals, (self)explanation, internalization, appropriation, shared cognitive load, mutual regulation and social grounding. Examples of educational forms in which cooperative learning is central are problem-based education and cooperative education (Barrows & Tamblyn, 1980; Kanselaar & Erkens, 1996; Ronteltap & Eurelings, 1997; Kirschner, 2000).

3.7. Process management

Computers can execute formally described processes, such as calculations, administration, transaction processes and workflow processes, extremely quickly and accurately. In addition, there is some talk of a certain measure of intelligence such as is possible with modern agent technology. This characteristic creates the possibility of letting computers carry out or support—partially or entirely—the administrative work in education. In this way, processes become manageable. Most educational institutions already make extensive use of these possibilities for educational administration.

New educational models that are based on such principles as personalisation, use of authentic learning environments and modern forms of assessment like portfolio assessment, are inherently complex when it comes to the management and administration that is necessary to steer processes in the right direction. The management of these processes is perhaps, one of the greatest barriers to undertaking educational innovation dynamically.[19] Computers allow us to implement modern, often more complex, educational models by reducing management complexity. Process management is also part of the educational-development- execution-evaluation cycle. There is a desire for high-quality, professional content that also offers at the same time maximum possibilities for adaptation and actualisation.
This introduces a tension in terms of cost-effectiveness, unless these processes are set up and managed intelligently. Information- and communicationtechnology can play an important role in the management of this process.

By the way, there is a snake in the grass when we talk about process management in relationship to reduction in complexity. If complexity decreases at one point in the system, it usually rises in another. The complexity is distributed throughout the system components, and can be shifted from one component to the other. I will give you an example. User-friendly, less-complex user interfaces require more effort from interface developers. Good, accessible study material that conforms to scientific research guidelines requires increased effort from material developers. The possibility, for example, to ask a teacher questions via e-mail simplifies the study process for the student, but substantially increases the tutor's work (Curran & Fox, 1996; Regalbuto, 1999). The complexity can be shifted:
(a) from actor to actor within the same process;
(b) from phase to phase of the life cycle;
(c) from underlying administrative system to the main educational system and vice versa.
The search for the right balance is one of the greater challenges in the design of learning environments.

3.8. Definition

In an electronic learning environment everything now comes together. This has the general characteristics of a learning environment. To this are added the following possibilities, based on the five central subjects that were discussed above:

1. An electronic learning environment can make optimal use of new, powerful, 'ideal' educational designs, because use is made of the representation qualities of computers.
2. An electronic learning environment's subsystems, such as students, staff and objects, can be distributed. On the one hand, this creates the possibility of gaining time- and place- independent access to the learning environment, for example from home or work. On the other hand, files can be managed centrally, so that large knowledge files and records, for example, can be constructed.
3. People are offered individualised activities and resources, depending on the role they have in the learning environment and on their personal file, which contains preferences, foreknowledge and situational possibilities. In this way they can focus their work, without being overwhelmed by the large amounts of information, people and materials that can be present in a learning environment. This limits the cognitive stress and focuses the attention (Sweller, Van Merriënboer & Paas, 1998).
4. Cooperation among people is promoted through group communication and application sharing[20], but also through version and change management, temporary workspaces, agendas and schedules.
5. Process management is, where possible, the province of the computer, including, for example, the management of workflows, the pointing out of problems, and the administration and presentation of tasks and resources at the right moment. Through this, more complex forms of work are made manageable.

The above can be concisely summarised in the once-again provisional definition that follows.

An electronic learning environment is a social system focused on the permanent development and certification of human knowledge and competencies in a specific domain, in which the subsystems can occur distributed in time and place, and in which ICT ensures integration, representation, personalisation, cooperation and process management.

4. **Between fiction and reality**

4.1. Introduction

Up to now it all still sounds like promises and fancy words. At the Educational Technology Expertise Centre I work with a team of specialists in the educational technology development programme to systematically explore to what extent we can make the fiction of electronic learning environments a reality, and where we have to readjust the fiction, if necessary. The trick, namely, is not to get bogged down in fancy rhetoric, but to give practical form to educational innovation. In addition, the danger, again, is that existing practices and preconditions will restrict things too much. Anyone who has implemented an innovation project in an existing context can join in this discussion (see, for example, Alexander & McKenzie, 1998). We have chosen to be as ambitious as we can be, to see what ultimately can be reached. Educational technology development that is focused on innovation is always located between fiction and reality.

Five tightly coherent programme lines are central to the educational technology development programme:

1. The development of new educational –philosophies, -concepts and –models, in close connection with continually innovative ICT possibilities, social requirements and theoretical insights.
2. The development of the methods and techniques that are necessary to realise these educational philosophies.
3. The development of prototypes in which new educational models, in essence, are made operational as working products and services.
4. The systematic testing of prototypes, methods and techniques in practice, to be able to assess their worth.
5. The systematic analysis, consideration and recording of the findings in scientific publications and reports, so that there is a body of knowledge about electronic learning environments.

Currently we are fully involved in what I call the first round of our journey through these five points. In addition, we have already achieved a few things, which I will tell you about shortly. Of course, it is impossible to give a complete overview of all the points. I will, therefore, limit myself to a number of core developments.

In the area of developing new educational philosophies we have recently kept busy primarily with the issue ‘competency-focused education in electronic learning environments’. We have analysed competency-focused education, designed an architecture for it and tested this in different contexts. This was all done based on the developments that were previously sketched out. For the second programme line, the development of methods and techniques, we concentrated on the question of how you can design, establish and exchange education in electronic learning environments, based on the demands we make on these.
For programme lines three and four, we developed a prototype of an electronic learning environment and tested it in practice at the Maastricht School of Hotel Management and in the Public Administration degree programme (Bestuurskunde) at the Open University of the Netherlands. The realisation of the prototype, together with the specification of diverse kinds of units of study and test material, was the primary test for the consistency of Educational Modelling Language (EML). The findings are recorded in a number of internal reports and diverse external publications are currently being worked on. Unfortunately there is not enough room to discuss these findings here.

This has not remained in the prototype stage, by the way. At the end of last year, we began a software-engineering process, which resulted in the first, complete, operational version of the system 'Edubox'. This system is currently being used for, among other things, the new competency-focused dual tracks of the Maastricht School of Hotel Management, in the Public Administration degree programme (Bestuurskunde) at the Open University of the Netherlands and at UNISA, the South-African institute for distance education. Start-up projects are also being set up for the Digital University and there are several developments to report in cooperation with publishers and educational sectors other than higher education.

To find out about the execution of competency-focused education in the development programme I suggest you read the text of Jochems' founders-day speech (1999). In what follows I will briefly show you what, in my opinion, is perhaps most important, namely the development of the notational method for education in electronic learning environments, 'Educational Modelling Language' (EML).

4.2. Towards a notational method for learning environments

In our analysis, the availability of a good notational system for recording the content and occurrences in the learning environment is a frequently underestimated condition for developing an electronic learning environment. With this kind of notational system it is possible to systematically work together on educational development, adapt high-quality instructional methods, create an economy of scale, get a handle on the quality of education and interchange the components that have already been developed (see box 4). I can also turn this around. Because of the lack of a good notational system we have problems adapting the present generation of electronic learning environments, for example, with cooperation, exchange and getting a handle on the quality.
Compare this, for example, with the possibilities that were created by being able to write down music. For centuries, singing and playing were the only ways to pass music on. This limited the possibility of creating complex compositions. Until, in the Middle Ages, musical notation was developed. Compositions for a multi-part orchestra became possible. Players no longer had to remember everything and composers could put their thoughts on paper. In that way, the music could be widely distributed and performed. A comparable story is true for the development of writing. In nearly all cultures the development of writing was connected to progress, culture and prosperity.

That is why we are working on the development of a notational system with which a learning environment, based on modern instructional premises, can be fully described. In addition, we require that a computer mustbe able to read this notation. A great diversity of educational models must be able to be described with the notational system. On the one hand, it must be able to support the transformations from existing to new educational forms. On the other hand, I think that a multiplicity of work forms is more often found in practice than education that is completely on one line. Certainly this is true if we look beyond institutions themselves to what exists among them.

In the following section, I will briefly review the assumptions that were used in the development of the notational system. I will talk a bit about the notational technique and will also briefly address the results so far. Apart from that I will restrict myself to a few high points and examples, because the technique and notational system are very broad.

BOX 4 The advantages of a notational system for learning environments

- Thoroughly *innovative* educational designs can be made. These designs can be implemented uniformly, as desired, in multiple courses or degree programmes.
- Different experts can *work together* on educational design and development. The notational system integrates everyone's work. This leads to education that is more professionally designed.
- In the development process there is not yet a need to considere the distribution medium, since the notational system is *medium neutral.* The choice of the delivery format and the design are made later, often automated, so that the production process can proceed with extreme efficiency. Currently a lot of time is often spent on such processes as design and text conversion. These activities will largely fall away, while high quality is still guaranteed.
- The notational system makes it possible to *exchange* units of study or parts of units of study among institutions, within institutions and among suppliers. Reuse of materials and designs are optimally supported by doing so, which greatly increases the efficiency of the development process.
- The notational system makes investments in educational development *future-proof,* because it is immune to ICT innovations.
- Explicit notation of the design gives a better handle on *quality*
- The uniform manner of recording provides a *research instrument* with which the structures and patterns of specific instructional models can be further investigated and related to their effectiveness. Results of the research can be described in the notational system as unambiguous examples.
- Recording the principle once and then playing it repeatedly on a device creates an *economy of scale*. This then creates the possibility to invest more in educational innovation and development so that higher-quality, and therefore more effective and attractive, education can be created in which the newest views on learning and instruction can be systematically incorporated.

4.3. Basic assumptions about the notational system

To begin with there is this question: what precisely is being notated? We have chosen to indicate the notational system with the term 'unit of study'. This term is more generic than the term 'learning environment'. A unit of study must be able to describe a learning environment and the subsystems that can occur in a learning environment, such as courses and course programmes. A unit of study can have an arbitrary scope. This makes use of the concept 'unit of study' extremely powerful. A unit of study can, in turn, also contain units of study. In this manner complex learning environments can be described. They are composed of relatively independent components that do have a common basis, thanks to the system's coherency. A learning environment, therefore, is represented by one unit of study that is described according to the principles of soft-systems theory. This unit of study contains a series of activities and subunits of study that can themselves be learning environments, or, for example, course programmes or courses (see figure 1). A unit of study is a systematic clustering of a series of activities focused on the achievement of specific goals, including the environmental components that are necessary to execute the activities. The environmental components can be used in more than one unit of study.

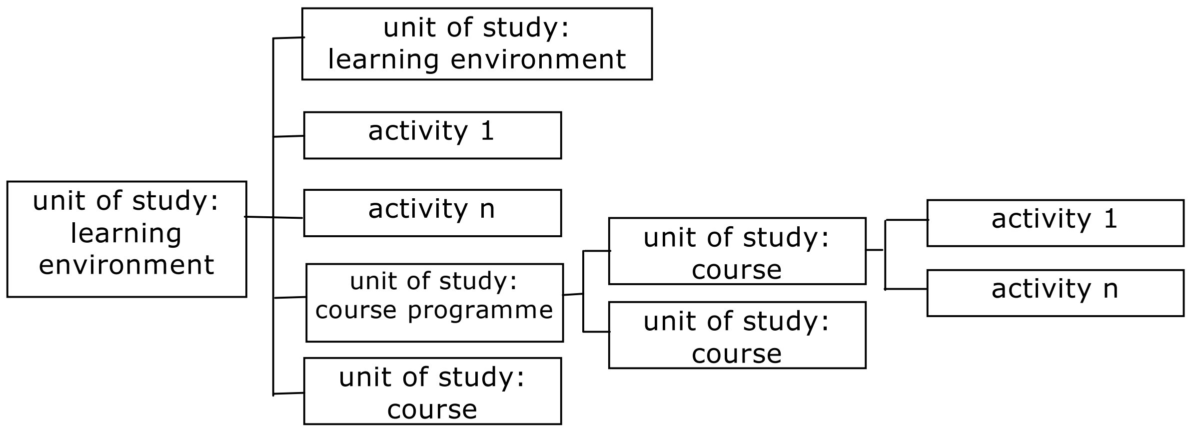

Figure 1. Example of the coherence among learning environment, course programmes, courses and activities

The next question we asked ourselves is: Which requirements does the notational system have to fulfil? We set out eleven:

1. The notational system must formally describe units of study, so that automatic processing is possible (*formalisation).*
2. The notational system must be able to describe units of study that are based on different educational philosophies (*pedagogical flexibility).*
3. The notational system must explicitly record the structure of the instructional components (*explicit instructional method)*.
4. The notational system must be able to fully describe a unit of study, including all content and all activities of all students and staff members (*completeness)*. And regardless of whether these aspects are represented by the computer or are present in reality.
5. The notational system must describe the units of study so that repeated execution is possible (*reproducibility*). The consequence of this is that no references can be made to concrete instances, such as information about time, place or people. This is all described abstractly. Cooperation among people and interaction between people and an object must also be able to be described abstractly.[21] The consequence is that an instantiation process is necessary before a unit of study is operational.[22]
6. The notational system must be able to describe personal aspects within units of study, so that the content and activities within units of study can be adapted based on the preferences, prior knowledge, educational needs and situational circumstances of users. In addition, control must be able to be given, as desired, to the student, a staff member, the computer or the designer (*personalisation*).
7. The notation of content components, where possible, must be medium neutral, so that users can choose the presentation medium as much as possible (*medium neutrality*).
8. When possible, a 'wall' should be placed between the standards that are used for notating units of study and the technique used to play units of study. Through this, investments in educational development will become resistant to technical changes and conversion problems (*interoperability).*
9. The notational system must fit with available standards (*compatibility).*
10. The notational system must make it possible to identify, isolate, decontextualise and exchange useful components, and to reuse these in other contexts (*reusability*).
11. The notational system must make it possible to produce, mutate, preserve, distribute and archive units of study (*life cycle*).

I would now like to go into more detail about five of these requirements: the need for explicit instructional methods, reusability, interoperability, medium neutrality and compatibility with standards (see also, Koper & Manderveld, 1999).

Explicit instructional models

The notational system must explicitly set out the unit of study's instructional model, regardless of the chosen teaching method. This means that the notational system must be based on a instructional vocabulary that is common in the instructional models that we currently know. With the notational system it must be possible to:

- describe instructional models that are based on an empirical, rational or cultural-historical philosophy[23]. Modern variations, such as competency-based education, cooperative learning, problem-based education and performance-support approaches[24] are also viewed;
- describe both open units of study, in which the student, the teacher and other actors can make choices during the implementation of education, and more fixed units of study, in which the designer has already established the choices.

The difficulty here is finding the proper level of abstraction. If the level is too abstract, then it does not really reveal anything more about the instructional design. If it is too concrete, it means that specific notational systems must be developed for an assortment of instructional models. A choice is made for the design of an instructional meta-model, based on an analysis of existing educational theories in literature along with a study of the human performance improvement approaches (Stolovitch & Keeps, 1999), the principles of systems theory as presented earlier and work that I had carried out in this area in the past. The meta-model consists of five axioms that we formulate as follows:[25]

1. A person learns by completing activities in an environment and by receiving feedback that comes from this environment.
2. An environment is composed of a collection of objects, living beings, and possibly sub-environments in a specific interrelationship.
3. When a person has learned he or she can a) carry out new activities or carry out activities better or faster in similar environments or b) carry out the same activities in another environment (transfer).
4. A person can be urged to carry out specific activities, if:
   - the task he or she is urged to do is well-formed and valid;[26]
   - the activities are able to be carried out by the person;
   - the necessary environment is available or is made available,
   - the person is motivated or becomes motivated to perform.
5. What has been set out here regarding an individual is also valid for a group of people or an organisation, even though this does not have to be reducible to individuals.

No value judgement is made in these axioms about the questions:

- What does a person or group learn (knowledge, competencies, skills, insight, attitudes, intentional behaviour) and in which domain?
- What kinds of activities must be carried out to learn? For example, observing, describing, analysing, experiencing, studying, problem solving, experimenting, predicting, practicing, exploring and answering questions.
- How should the environment be arranged (context, which people, which objects) and what relationship does the environment have to the teaching-learning process?
- To what extent is the environment present externally and to what extent is it represented cognitively-internally?
- What precise form does the feedback take and how is this received?
- How, precisely, do the learning and transfer processes occur?
- How is motivation stimulated?
- How exactly does assessment occur?
- How should activities be stimulated?

The answers to precisely these questions determine the educational philosophy, the instructional model and the instructional scenario. The meta-model provides the semantic framework for the units of study's notational system, alongside the structure of learning environments that was dealt with earlier.

Reusability

Educational development is intensive and expensive. The reusability of educational content and instructional components is often limited, for example, because developers do not know that certain components exist or because these cannot be easily obtained for integration. Reusability has a number of consequences, the most important being:

- Identification of and search for parts;
- Identification and correct handling of authors-rights issues;
- Isolation and decontextualisation of parts;
- Assembly of parts

Making components reusable delivers many advantages, primarily more efficiency. The technique, however, is not simple and requires clear agreements about the standards to be used.

Interoperability and medium neutrality

According to a famous saying, knowledge is as transitory as fresh fish. This is also certainly true for technology, particularly ICT. In years past we have seen a variety of technology come and go. Content that was made available, with great effort, in a specific format, is now often no longer usable, unless large investments are made for conversion. Another point is that those in cooperative work relationships often wish to use each others work, but will then want to give it their own interpretation, for example if an institution for face-to-face education wishes to use material that was made for distance education. In many cases, this is not possible because the design is too closely tied to implementation-specific aspects, including the choice of media. In addition, we have already touched on the point that in the execution those involved would still like to be able to choose another presentation format.
To be able to answer all these points, it is assumed that the notational system standards for the units of education were disconnected from the standards and format for the execution of these.
A 'wall' is truly placed between educational development and educational execution. This means, first of all, that there is no dependence on suppliers when it comes to encoding educational content and second of all, that units of study, and parts of them, can be exchanged. The third advantage is that encoded units of study, in principle, can be run on all current and future hardware. In the forth place, education can be used in different implementation situations, for example, in face-to-face instruction, distance education and dual education. An additional advantage is that educational developers can concentrate on education and do not have to take into account platform and presentation aspects. If people are well trained in this, it is much more efficient. A condition, however, is that everyone involved adopt the notational system.

Compatibility with standards

In this world there are many initiatives that try to achieve interoperability by developing (proposed) standards with a broad base. This concerns general specifications, such as those for the binary representation of writing systems in assorted languages (Unicode) or exchange languages such as Standard Generalized Markup Language (SGML, Goldfarb, 1986, ISO 8879), HTML (developed by Berners-Lee in 1989) and Extensible Markup Language (XML, Bray, Paoli & Sperberg-McQueen, 1998). This also involves specific specifications such as those for instructional components and architectures. Consortia and committees keep busy with these discussions or with the development of specifications, such as IMS (http://imsproject.org), the open e-book standard initiative (http://www.openebook.org/), ISO/IEC JTC1/SC36 (http://jtc1sc36.org/), IACC (http://www.aicc.org), IEEE LTSC (http://ltsc.ieee.org/), Dublin Core (for example, Weibel, Kunze, Lagoze & Wolf, 1998), Ariadne (Forte, Wentland-Forte & Duval, 1997), CEN/ISSS/LT (http://www.cenorm.be/isss) and Prometeus (http://www.prometeus.org/).

Because of the large number of participants, the industrial interests, the cultural differences and the multiple procedures, this kind of standardisation process proceeds extremely slowly. Given the tempo necessary for the development of electronic learning environments, waiting for the development of standards is currently not an option. An enormous advantage of this approach is that final consensus is reached. A disadvantage is that the standards themselves include rather large compromises and frequently avoid tricky subjects. This is why the commissions that are busy with learning-related standards do not currently concern themselves with educational modelling (recently an instructional design working group has been started in the IMS consortium). In general, a rather technical approach is chosen, in which, for example, the exchange of learning objects among educational applications—or of interfaces with administrative systems—is central. Currently, for example, subjects under discussion include metadata, learner profile information, and content packaging. No attention has (yet) been paid to the modelling of the actors' activities in the educational process, and no integral notation language has been developed for units of study or instructional models. Parts of this notational system, however, are under discussion, so that when we designed Educational Modelling Language we required that this must be compatible with the standard initiatives and that the duplication of work should be avoided. We will also strive to contribute to the relevant committees. I have concluded that the contribution of educational technology must be strengthened, so that instructional (cq educational) modelling is placed on the agenda.

4.4. Educational Modelling Language (EML)

The notational system for units of study, which we named Educational Modelling Language (EML), is implemented with the use of internationally accepted meta-language Extensible Markup Language (XML). XML, in turn, is based on the ISO-standard SGML. With the help of SGML and XML, it is possible to develop a domain-specific vocabulary, such as is needed for the notation of units of study. This is, by the way, not just possible, but also necessary. Use of XML without a vocabulary is meaningless. The development and testing of a domain-specific vocabulary usually takes a number of years. Except for EML there is currently no extensive XML vocabulary with which you can specify education.[27] It is also true that EML is really an architecture that can be implemented in a number of meta-languages. For example, we currently use the document-type definition standard for the implementation, or 'binding' as it is currently known, of EML. In the future, this can also be converted, for example, into a Schemata Standard, such as that which is currently being developed by the World Wide Web Consortium (http://www.w3c.org/). EML's basic structure is shown in figure 2.

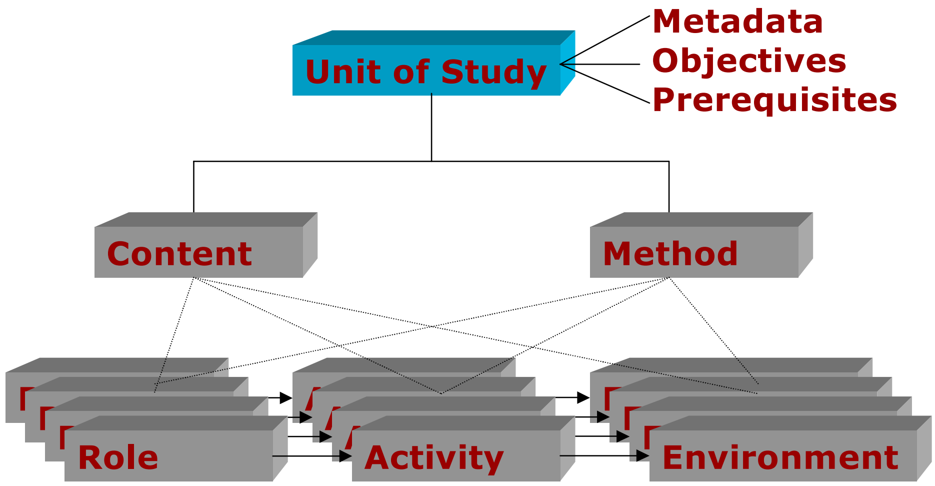

Figure 2. The structure of EML

Working this structure out in XML yields, at a primary level, the structure in figure 3.

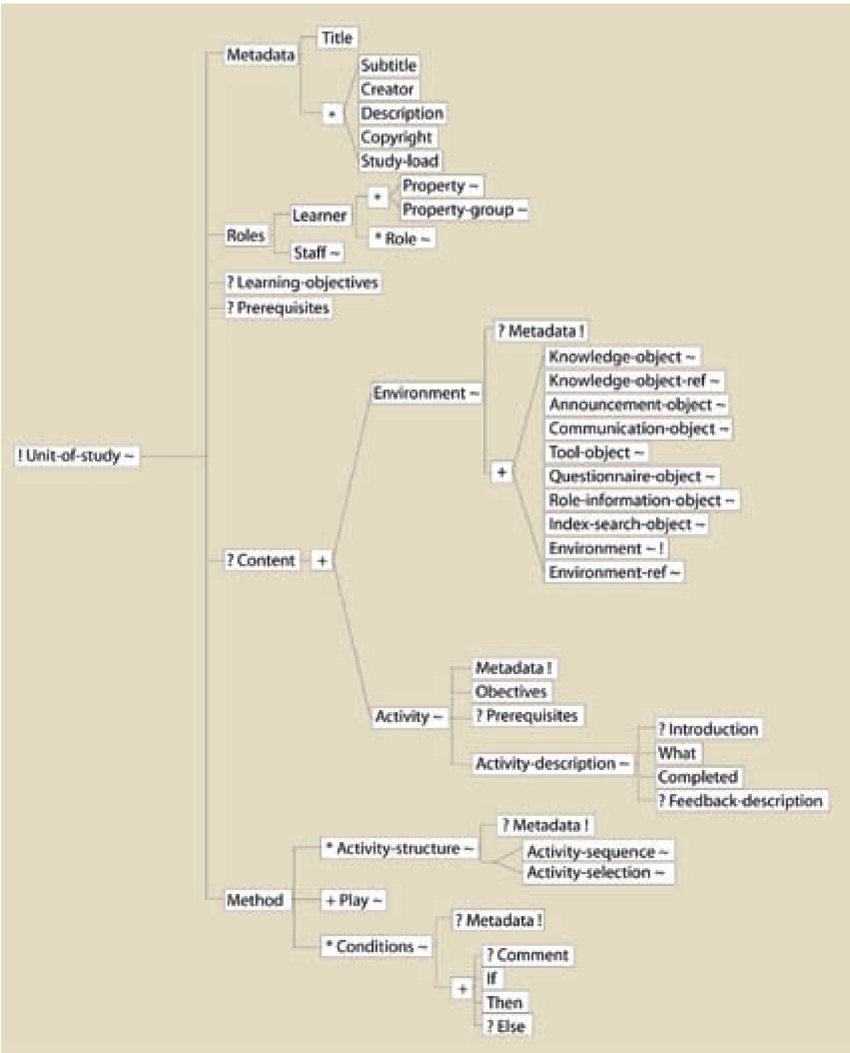

Figure 3. EML displayed in an XML tree structure

EML was developed in a number of beats. A large number of practical tests were conducted, after which the notational system was continually adapted according to the results. Part of these tests included construction of a system that reads the notational system, a reference system. We will supply still more EML -changes, and especially, -extensions for the future. That is why we have made the structure 'open', so that these sorts of changes can be accommodated without the existing material having to be adapted. It is extremely important that materials made in EML are compatible with future versions.

4.5 Designing learning environments

So, the units of study can be described using EML. The next question that arises is how you move step-by-step from the basic idea of a unit of study to a complete, written notational system for it. EML records the results of a design process, but it does not facilitate the designing. In the preliminary phases all conceivable educational design methodologies are suitable, at least to the extent that they lead to a medium-neutral design. Currently, however, there is a shortage of sufficiently appropriate design methodologies for electronic learning environments that are described using EML. In the future, these must be developed further. One possible approach is the following, which can be traced back to, among other things, the methodologies that were developed to describe social systems and which, in an adapted form, might just be useful in the development of units of study (see, for example, Nadler, 1981; Koper, 1995; Banathy, 1996a, 1996b; Checkland, 1999). The core of this methodology is that it uses normal Dutch language, or another random language, as a resource for the design process. Sentences must also be formulated. These must meet specific requirements, for example by appearing in the following format:

R (with characteristics K) carries out activity A in environment O (with D as an objectivel).

This results in a conceptual model of the activities in the unit of study. These can be worked out into a instructional scenario (Koper, 1995). That is to say, a complete description of all activities, carried out by all the roles in a logical relationship. Through this there arises a kind of structured 'story' about the activities and events in the learning environment. The touchstone for consistency is always a instructional model. That is to say, the glasses through which the problem is viewed. The instructional scenario can now simply be converted into EML. The personal pronouns describe the roles. The verbs describe the activities. The nouns describe the objects in the environment in which the activities are carried out, and the network of inter-dependent activities determines the sequence. More detailed refinements can be added later, particularly if these involve individual preferences and alternative learning paths. The educational content and task descriptions must also be worked out in more detail at a later stage.

It is wise to realise that the final design must meet the earlier established requirements, of which EML and the design methodology both guarantee portions. This means, for example, that the design must be set up in such a way that the results contain explicit instructional models and are replicable, medium-neutral and reusable. More must be invested here, but the result is that notated education can be able to be used, wholly or in part, in different educational settings and in different media.

4.5. Examples

What follows are a few examples of the notational system and the interpretation of this in the Edubox-player. The player architecture and technique cannot be dealt with here (see figure 1 in Jochems' contribution to this collection).

The first example (figure 4) involves the notational system for a simplified unit of study without content. This gives an impression of the manner of notation. Elements are shown between brackets. Each element has a beginning and an end. The end is represented by a '/' within the bracket. Elements can contain attributes such as identification. These are represented *in* the element, for example id='naam' (name). Elements and attributes with the term -ref in the name indicate elements or attributes specified elsewhere. The play forms the core of the notational system. Written there in ordinary Dutch is: 'De rol ontwikkelaar start met het uitvoeren van de activiteit instellingen'.(The role of developer starts with executing the activity settings) If this is achieved, students can start to work on the introduction of the activity. Thereafter there are a number of activities that must be carried out together.

```
<unit-of-study>
  <metadata>
      <title>Competency: policy recommendations</title>
  </metadata>
  <roles>
      <learner id="Student">
          <property id="Learning Style"><integer/></property>
      </learner>
      <staff id="Tutor"/>
      <staff id="Developer"/>
      <staff id="Evaluator"/>
  </roles>
  <method>
     <play>
            <role-ref idref="Developer"/><activity-ref idref="Initiation"/>
                <continue><when-completed/></continue>
            <role-ref idref="Student"/><activity-ref idref="Introduction"/>
                <continue><when-completed/></continue>
            <role-ref idref="Student"/><activity-ref idref="competency test"/>
            <role-ref idref="Student"/><activity-ref idref="competency-1"/>
            <role-ref idref="Student"/><activity-ref idref="competency-n"/>
            <role-ref idref="Rater"/><activity-ref idref="review"/>
            <role-ref idref="Evaluator"/><activity-ref idref="evaluation/>
     </play>
  </method>
</unit of study>
```

Figure 4. Sample notation for a unit of study. Simplified notational system, without content.

Both the activities and the objects that are used in the implementation of the activities are specified externally in the example. In using this piece of EML in an Edubox-player the following must happen:

1. The linking of real people to specific roles.
2. Decision-making about the setting, such as face-to-face- or distance- education, and the roles for communication media, for example, face-to-face, e-mail or telephone.
3. Decision-making about the primary presentation media for information, such as the web, a book or an e-book, and about the amount of freedom a student has to choose this media.
4. Decision-making about the design, if there is talk of a house style.
5. Decision-making about the language of the interface and other details.

When these choices are made we speak of specific publication of the education; it is made suitable for the specific circumstances in which it will be used.

Based on the example above, you can imagine that the teacher creates the settings using a web browser and that the student reads the introduction in a book printed from EML. Another possibility is that the student is offered the introduction via the web or videoconferencing. These are all medium-specific choices about which EML says nothing, but which are determined upon publication of EML.

In figure 5, you can see part of a knowledge object consisting mostly of text. The 'special' codes make it clear that special operations are defined for these text pieces, for example, 'profile-dependent' or 'as desired' are left out. Because these texts are specified as medium-neutral, they can, in principle, be given a number of different forms and be made available into a veriety of media, for example, on paper (high-quality print rather than a screen print).

Figure 5. Knowledge object with textual content. Source: Public Administration degree programme (Bestuurskunde), Open University of the Netherlands, 2000

Figure 6 shows the Edubox player for a unit of study, seen from the role of the student. Other roles, such as that of the tutor, see other activities and work environments. Depending on what is specified in the play, the student, at any given moment in time, sees a different collection of activities along with the objects that belong in the work environment. Finished activities are crossed off.

Figure 6. A unit of study as interpreted by Edubox, seen from the role of the student. Source: unit of study for Local Administration degree programme (Gemeentekunde), Open University of the Netherlands .

The next figure (7), finally, gives an impression of the work environment that is used in a specific activity. This environment can differ per activity.

Figure 7. Work environment in an activity. Source: Basic Management course at the Maastricht School of Hotel Management.

5. From change to renewal

We are now nearing the end of this address. I have defined, in detail, the concept of electronic learning environments within the context of systems theory. I have shown you that this does not involve, for example, a walking encyclopaedia or a digital learning platform, but rather comprehensive, flexible, rich environments in which human activity is central to the learning process. Information- and communication- technology also play an important role here, one without which the process would be impossible.

I have also told you that we in the educational technology development programme try to make reality of fictions, such as those that are present in the use of ICT in education. That is how we recently developed and tested a method to notate education, so that one of the most important conditions for realising electronic learning environments can be met. The notational system makes possible cooperation among institutions by seeing that people are not hindered by the coincidental ICT possibilities of this time. This also establishes a powerful basis for the future, although much still has to happen to achieve large-scale, practical and successful implementations.

In the introduction, I stated that one of the great questions of the moment is what the development of electronic learning environments means for existing educational institutions. I stated that it can *no longer* be sufficient to make small adjustments to the existing educational systems, but that a thorough renewal is necessary to fulfil the changing societal need. In systems theory, in general, it is true that if the higher-order systems change, it is necessary to adapt the subsystems to survive. The higher-order systems will only continue to support the subsystems as long as the subsystems continue to fill the higher-order systems' needs (Hutchins, 1996). The question that must systematically be asked, therefore, is: are the social systems currently so changed that the educational system, as a subsystem of them, *has to be* adapted?[28] The social changes about which I previously spoke, such as increasing heterogeneity and interaction, the increase in globalisation, the increased need for 'knowledge workers', the rapid obsolescence of knowledge, the increasing tempo of changes, all of which are inextricably tied to ICT developments, indicate a strongly changing need for education.

To be able to provide for this new need, institutions for education and training, in my opinion, will primarily have to keep busy in the future with offering electronic learning environments in which people can—efficiently and effectively—acquire knowledge and develop competencies their whole lives and as desired. What follows from this are not 'dead' mechanistic computer applications with an abundance of structured teaching materials. Human activity and interaction must be central in learning environments. People meeting people and learning with people. The activity occurs in a variety of natural or designed contexts. In the latter case, with a rich, varied, professionally made and optimally pertinent content. The activities and contexts can be adapted to individual wishes and possibilities. The learning environments are available at a distance, so that they can be accessed from a mobile device, at home or from work. Electronic learning environments do not preclude classical education, and certainly not personal contact among people. It is true that this will more often be mediated by ICT. A person's available knowledge and competency levels will be systematically charted, certified and stored in a personal file. In this way, a person can show the labour market which knowledge and competencies he or she has, so that employability increases. Those who want to learn something or acquire a qualification, can, on the basis of their current and desired profiles, get a customised educational arrangement, in which only that which is strictly necessary will be on offer. Characteristic is that educational institutions will be completely devoted to serving the individual's development and the social request for highly educated 'knowledge workers'.[29]

The realisation of this vision also makes considerable demands on the methods and techniques with which electronic learning environments are developed and offered. I have shown you that we have laid a strong foundation. In the coming years in the development programme, however, we will still have to work more, expressly on the question of how electronic learning environments can be designed and used as effectively, efficiently and attractively as possible. In addition, further practical validation of the concepts and instruments is particularly necessary. There are still such questions as: which work processes work well for development and guidance, and which do not? How do you test and certify competencies and how do you exchange information about this in a uniform manner? Which personalisation is—and is not—advisable? How do you establish personal educational arrangements, what do you design beforehand and what occurs in real time? How do you organise education in which a mixture of face-to-face and distance- education is used? How can you reuse design as optimally as possible and promote cooperation among parties in the development- and execution- phases? Facilities that improve the user-friendliness and representation of learning environments at a distance must also be continually examined in a technical sense. In addition, much experimentation must be done on smaller and larger scales to test new principles in realistic contexts. The working methods we use to elaborate on these questions must be action-focused where possible (see also, Reeves, 1999).

An action-focused manner of development in educational technology is, in my opinion, crucial for driving real innovation. All this to prevent us from getting bogged down in fancy words and fierce discussions, and also to distribute convincing stimuli. Look, we can also do it this way, different and better. That is precisely the characteristic of a social technology that is focused on improvement. As I have already said, the end of this journey is far from over. But on the way from change to renewal, we have already travelled quite a way.

Notes

[1] The work I am talking about took place in the educational-technological development programme at the Educational Technology Expertise Centre (OTEC), under the management of the Open University of the Netherlands. I would like to extend special thanks to the many dozens of people, working inside and outside of the Open University of the Netherlands, who have been involved with the development programme over the years. Unfortunately I can't name them all here. But the supplement does include a list of internal reports to show some of those who have worked on this project.

[2] See also the advice given by the Socio-Economic Council (Sociaal Economische Raad) in note HOOP 2000.

[3] Equipment, by the way, is an important condition. What I'd like to emphasise here is that providing equipment is only a part of the process, and must not remain limited to that.

[4] See, for example, Koopmans 2000 for a discussion about future variations and Sloep and Schlusmans (yet to be published) for a description of the Digital University's future and challenges.

[5] The concept 'learning environment' is also confusing because it indicates the environment 'of something', in which it is often unclear whether the 'something' is a part of the environment or must be viewed separately from it. Take, for example, the following situation: 'I study the book in my room.' The room, including the furnishings, can be considered the learning environment, but so too can the room plus the book, or even the room, the book and myself as the person in the room. This becomes even more complicated if other people who are being addressed are also present in the room. In this case, *my* view of the environment differs from that of the other. It becomes more complicated still when consideration is given not only to the static view of the environment but also to the dynamic view: the communication among people and their interactions with the objects that are present there.

[6] Salomon's opinions about learning environments are rather similar to mine, but, in his developments, he situates the learning environments primarily in ordinary classical educational environments, in which the teacher has the responsibility. The concepts that he uses would, in my opinion, have to be more generally formulated in order to be usable in distance education, distributed education and performance-technology approaches.

[7] Checkland (1999) consistently calls social systems 'human activity systems'.

[8] The examples cited come from Salomon (1996, p. 368).

[9] Of course, this definition is normative. Yet I have kept it so broad that this definition encompasses both the concept of powerful learning environment and also that of simpler approaches such as the classroom or the university as a learning environment. It is precisely this broad approach, which also includes modern educational views and new views of system theory, which makes this a definition of a flexible learning environment. This adjective is not used here as an indication in the manner of 'new' or 'modern'. After all, it still concerns a learning environment in a certain definition.

[10] Other definitions of knowledge are permissible here. Characteristic is that knowledge is considered broadly and not in the narrow sense of knowledge, insight, skills and attitudes. Barnett (1996) preferred 'understanding' rather than knowledge in this context.

[11] The terms 'consciously' and 'responsibly' overlap to a certain extent and are rather vague. The advantage is that everyone has his or her own intuitive concept of these terms. In literature many different, more accurately defined terms are available. These illuminate specific aspects such as self-efficacy (Bandura, 1982), meta-cognition (Flavell, 1979), cognitive ability (for example, Plomin, 1988), social ability (Fiske, 1992) and self-regulation (Shuell, 1993). The terms are also very close to generalised philosophic notions such as free will, self-determination, responsibility and rationality. Assorted definitions of competencies are also available (for a summary, see Verreck & Schlusmans, 1999). There is, as yet, no conceptual framework that is widely accepted.

[12] The terms 'task' and 'instruction' are considered synonymous here. Tasks can be ordered hierarchically and can be bundled into courses or course programmes, for example. A learning environment can contain more than one course or course programme.

[13] See http://www.ou.nl/coo-catalogus

[14] It is important to note that I am not talking here about a separate teaching environment, as others do. That, namely, involves the view of the role of the teacher in the learning environment. Teaching environments, developmental environments and the like are all subsystems of the learning environment. The designated roles and activities are supportive.

[15] Characteristic of the three eras is always the question what constitutes a system and what the environment of a system. In classic instructional-design approaches the person learning was considered the system and the instruction the environment of the system (cf. Gagné's external conditions, 1965). In message-design approaches, the form in which the curriculum content is offered is central, taking into consideration the manner in which the subject matter is processed cognitively. In the design of learning environments, by contrast, neither the cognitive processing or the subject matter's form is central, but rather all human activity that focuses on learning something or on helping someone learn something, and the environment or context in which these activities take place. By the way, the term 'instructional design' is used in the classical sense here. Since a term can be redefined, the design of a learning environment can also be considered as instructional design in the new sense.

[16] In educational literature, the concept 'simulation' is frequently considered more narrowly than is intended here (see, for example, Reigeluth & Schwartz, 1989; De Vries & Huisman, 1990; De Jong & Sarti, 1994; Van de Ven, 1998). Gredler (1996) defines simulations, for example, as experimental exercises. I use the concept more broadly and generally here, namely as the property of a computer to imitate systems and, therefore, components of learning environments.

[17] The fact that users can make up a part of the system distinguishes computers from television, for example. In films too, systems are represented in a true-to-life manner, including their dynamics. However, here the user is a spectator rather than a part of the system, and therefore, cannot interact or communicate with, for example, the film's main characters.

[18] A comparable viewpoint when it comes to organisational design can be found in Ackoff (1981) and Nadler (1981).

[19] In commenting on the implementation of Glaser's (1977) models for macro-personalisation of education, Park (1996, p. 638), for example, suggests that: '(…) the development and implementation of an adaptive instructional program in an existing system are complex and difficult. This might be the primary reason why most macro-adaptive instructional systems have not been used as successfully and widely as hoped. However, computer technology provides powerful means to overcome at least some of the problems encountered in the planning and implementing of adaptive instructional systems.'

[20] Application sharing includes the notion that the same application can be seen by several people simultaneously. If one person makes a change, therefore, the others see it almost immediately.

[21] Much of the information in cooperative environments, by the way, develops in real time. Given the requirements for reproducibility, this information is *not* incorporated into the notational system, but must be processed in real time using adequate cooperative resources.

[22] In conjunction with this we talk about the 'run' of the unit of study. This instantiation includes, for example, the assignment of real people to roles, making available the correct numbers of necessary non-electronic sources and the determination of a time to start and end.

[23] In educational technology there is talk of different streams in which the characteristics appear to have what Thomas Kuhn (1962) describes as scientific paradigms. According to the *empirical approach,* as typified by Locke and Thorndike, all reliable knowledge is based on experience. Locke also says: 'There is nothing in the mind that was not previously in the senses.' The assumption is that behaviour is predictable based on specific environmental conditions, that processes are analysable and that in isolation, that is to say outside the context, they can be analysed and influenced.

In the *rationalistic approach,* as typified by Descartes en Piaget, thinking is considered the only reliable source of knowledge. In this case, it is supposed that cognition mediates the relationship between a person and the environment. As there is the possibility of large individual differences in cognitive processing, for example, because of differences in foreknowledge (Dochy, 1992), meta-cognition (Flavell, 1979; Brown, 1980), motivation (Malone, 1981) and learning styles (Vermunt, 1996), the assumption of predictable behaviour falls away, and those involved must work with more open, authentic environments in which students themselves can build knowledge. The student is given a central, self-managing role in the educational process (Shuell, 1988; Schunk & Zimmerman, 1994).

The third approach is called the *pragmatic and cultural-historic* approach, as typified respectively by James, Dewey and Vygotsky, Leont'ev, or in educational theory as social constructivism (Simons, 1999). In this approach, the situation and the cultural-historical context that a student is in are given primary attention (Lave & Wenger, 1991; Cole & Engestrom, 1993). Knowledge is distributed among individuals, tools and communities, such as those of professional practitioners. There is talk of collective as well as individual knowledge. Learning is considered as the adaptation of behaviour to the rules of the community. An important instrument for adapting and acquiring common views is discussion and cooperation in the communities.

[24] These approaches are supplementary and offer different perspectives on the same themes (see also: De Boer, 1986; Molenda, 1991; Greeno, Collins & Resnick, 1996; Sfard, 1998; Jonassen, 1999; Roblyer & Edwards, 2000). Just as psychology, economy and biology look at human behaviour in different ways. In the educational sciences the tendency is often to have strict, biased preferences for one or the other approach. In my view this is not acceptable for educational technology as a discipline. The instrumentation with which educational problems are examined are, in that case, seriously constricted (see Sfard, 1998). Add to this the fact that our current scientific knowledge about basic subjects such as the role of knowledge, cognitive processes, motivation, the role of social contexts and the relationship with the measures taken to activate learning processes, is still very limited and fragmented, and in practical applications must still be substantially supplemented with ad-hoc solutions (see Bereiter, 1990).

[25] Also compare the following citation from Duffy & Cunningham (1996, p. 171): 'As the quote from Skinner suggests, everyone agrees that learning involves activity and a context, including the availability of information in some content domain. Traditionally in instruction, we have focused on the information presented or available for learning and have seen the activity of the learner as a vehicle for moving that information into the head. Hence, the activity is a matter of processing the information. The constructivists, however, view the learning as the activity in context. The situation as a whole must be examined and understood in order to understand the learning. Rather than the content domain sitting as central, with activity and the "rest'' of the context serving a supporting role, the entire gestalt is integral to what is learned.'

[26] The criteria for well-formed and valid tasks are summed up in Koper (1992).

[27] Diverse limited vocabularies, such as Tutorial Mark-up Language (http://www.ilrt.bris.ac.uk/netquest/about/lang/ motivation.html), do exist.

[28] See also Reigeluth (1999).

[29] For a treatment of the concept 'competency' and its practical meaning see Buskermolen, De la Parra & Slotman (1999) en Schlusmans, Slotman, Nagtegaal & Kinkhorst (1999).

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