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Didactical Design of Telematics-Based Educational Material

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Abstract

Information and Communication Technologies are rapidly growing together: Starting from this hypothesis I will demonstrate consequences for teaching and learning, when the "Computer" is converting to a "Communicator". In the presentation I will attempt to show the expected or already observed changes and evaluate them along the criteria of human communication needs and explain them along methodological categories and draw conclusions for the design of educational software.

One of the most important difference of telematics-based against "normal" educational software is the direct advantage of supporting the communication between the teacher – and sometimes with peers, while conventional educational software represents only an asynchronous communication with the program developer.

It will not be possible to give a complete picture of all effects of telematics on all forms of teaching and learning. In spite of the rather broad hypothesis given above, I will refrain from developing long term prognoses and visions of the future, but will concentrate on those possibilities, that are already or will be shortly available for schools and universities. So I will not talk about video conferencing via broad band channels or full scale multimedia or hypermedia interactive networking on high speed lines.

Thedidactical design of the educational software of all categories discussed in our context need to be designed after the criteria applied in software development but also complying to the didcatical criteria as an other educational material. In this context some considerations and examples will be presented.

Contents

1. Didactical considerations for teaching and learning supported by educational software

1.1 Didactical paradigms

Presently we find only rudimentary methodologies for the application of educational software within the teaching at schools and universities. While the discussion within the schools has made some progress, it can be noted that media-oriented methodology is pratically no topic among academic teachers. Instead there still seems to be a broad consensus about some principles, which have been listed by Thissen in a recent presentation [Thissen 1997]:

„ • In principle the content can be conveyed to the learner.

- The teacher (as expert) knows, what the learner will have to know in future and therefore has to learn it. He knows, what the learner needs.
- The teacher approcximately knows the learner's learning process and can control it.
- It exists an optimal method of knowledge transfer.
- Knowledge can be transmitted from the teacher to the learner by language (textual or pictorial language).
- It is the teacher's task to produce the answers .
- It is the learner's task to more or less passively absorb the learning content and to store it in his memory. In this way he stepwise acquires the teacher's knowledge. [...] "

Thissen calls these principles „Myths about Teaching and Learning", founded on the „Nuernberg Funnel" paradigm, and suggests to found a new methodology on the basis of the constructivistic model of learning, which will be especially useful in the context of the development of educational multmedia software.His conclusion are:

„ • Learning is an active process of constructing knowledge [...] always and only in conjunction with already present knowledge. [...]

- The learner has to be active during the construction of knowledge. [...]
- Learning is an individual construction of a human mind. [...]
- Knowledge is not transmittable. It is impossible for the teacher to directly convey his knowledge to the learner. On the contrary, the teacher can only – by actions, hints, questions and information – assist the learner to construct his own knowledge. [...]
- The initial objective is to rouse the right questions in the learner. Only when relevant questions have been roused in the learner, the learning process is initiated on its own. [...]
- Learning means to design mental, cognitive maps, which will be more detailed and refined. [...] "

1.2 Influence factors on the design of teaching/learning processes

In a rough model we can identify the most important factors influencing the design of teaching and learning processes.

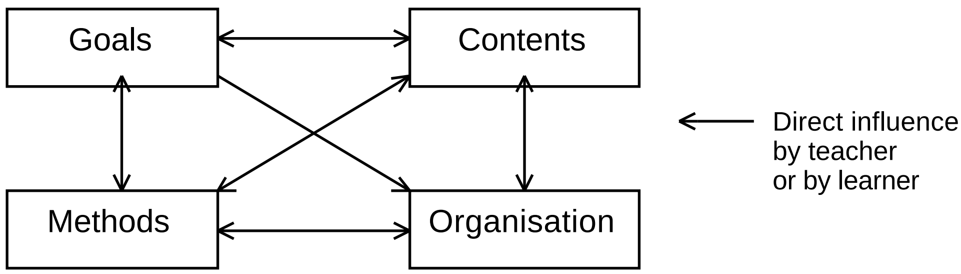
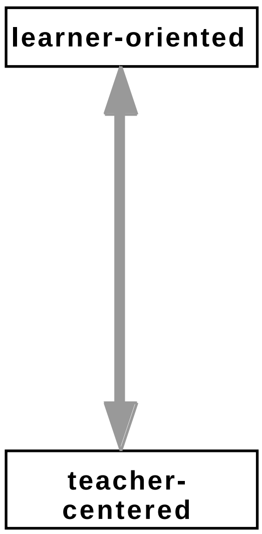


Fig. 1: Influence factors on the design of teaching/learning processes [Meyer 1991]

Within our discussion we will use this model to structure the design process, because it can easily be combined with the approaches applied in software development for the purpose of developing educational software.

Also for our purposes we categorise educational software following its orientation towards a self-organised open learning versus a teacher-directed learning.



- problem-solving tools – modelling micro worlds (specialized programming environments)
- intelligent problem-solving tutorials (intelligent tutor systems)
- kowledge acquisition by data organisation and data presentation (textual, numerical, pictorial), e.g., writing/structuring, drawing, ordering etc.
- communication tools and -media (including cooperative learning)
- informations acquisition
- simulations (exploring model worlds / micro worlds)
- role playing (with the computer as bookkeeper and/or partner)
- tutorial programs
- drill&practice programs

Fig. 2: Categories of educational software ordered after learner orientation

1.3 Structure of this presentation

In Chapter 2 we will investigate the technical possibilities of telematics : first for communication purposes in educational settings, thereafter the special conditions for educational software. Chapter 3 is devoted to the description of scenarios in educational settings, where there has been made use of computer-mediated communication. The methods used in Software Ergonomics to develop software conforming to the usability requirements will be discussed in Chapter 4. These methods will be combined with didactical requirements, so we will have some guidelines for the design of educational software (Chapter 5).

2. Technical possibilites of the Internet

2.1 Technical possibilities for communication processes

The technical communication possibilities influence heavily the organisational possibilities in teaching and therefore also the contents and methods of teaching (see fig. 1). The Internet offers communication, which can be described with metaphors from traditional communication forms:

- letter exchange
  + person-to-person
  + with a group: one-to-many, mailing lists
- bulletin boards (newsgroups),
  e.g., schule.umwelt.aquadata
  schule.informatik.curriculum
- libraries (information server access, information retrieval systems)
- annotated multi-media documents (World Wide Web)

Additional internet possibilities not further considered in this paper are:

- ftp (file transfer from/to other computers via internet)
- chat (online-exchange of short text messages)
- audio/video-conferencing

(While all forms are supported by the normal internet protocols audio/video-conferencing is only possible with special transfer protocols, which care for non-interrupted file transfer.)

2.2 Technical platforms relevant for telematics-based educational software

Technical support of communication processes

WWW – distributed hypermedia-system

- interactive access and navigation
- net-based
- multimedial
- hyperlinks between documents (pointers to locations in documents)

HyperWave (Hyper-G) – enhancement of WWW functionality

- improved navigation
- interactive annotation of documents by users

Extension of WWW by Java-Applets (and various "plug-ins")

- automated down-loading of Java-programs
- interactive use of Java-programs

2.3 The present situation in German educational institutions

While it is still not very common for German teachers today to have a private computer, we find surveys that every other pupil in Germany in the 7th grade (approx. 13 years old) can use a PC at home and that 70 % of all pupils have some kind of computer access [Rohe-Krebeck 1993]. The percentage for teachers at tertiary educational institutions is higher, but still far from 100 %. According to some estimations every secondary school in Germany has at least one computer cabinet with an average of 12 PCs, mostly linked in a local area network. While there is a 100 % internet connection to university and colleges (but not to all desks of the faculty staff), there are only a few hundred schools that have direct or indirect access to wide area networks. With the current development in mind this number willincease rapidly, because there are many new internet providers, who offer access to their services at local call telephone rates, so that one of the biggest obstacles – the high telephone bills for schools, when using the internet on long distance lines – will disappear in near future.

It is realistic to assume, that within only a few years teachers and pupils, lecturers and students in secondary schools and universities will have broad access to telematics systems, and that many teachers and learners will have their private computers connected to networks. The development in other West European countries is not differing very much from the German situation.

2.4 Human communication and telematics usage

Basically the networks support a broad range of human communication forms. This report will stress those forms, which will be accessible by schools in the nearer future - technically and economically. I will restrict myself to asynchronous communication with a textual or visual representation of the information (no audio/video conferencing). This means we will talk about:

- sending a message to recipients arriving there with a considerable time delay (i.e, seconds, minutes or hours later), analogous to telegrams and letters. This textual communication is based on a character code system such as ASCII. Thus it does not allow to transfer sound or pictures directly; but after the picture or sound file has been coded into an (illegible) ASCII-string it can be handled as a normal text file. Many mail programs allow to attach such non-text files (coded and compressed) to a mail, so that the mail recipient will be able to work with the file after an inverse decompression and decoding. (This technique is also used to tranfer text files containing non-standard ASCII coded characters, e.g., special characters in a certain language.)
- viewing messages, which have been published as „postings“ on an electronic bulletin board.
- accessing multimedia files, which have been „posted“ as html-documents on a WorldWideWeb server. They can be transferred to any other WWW browser on demand, so the recipient can view the texts, images or movies or listen to the audio files. Besides, these files can contain links to almost arbitrary spots in other transferrable files, so they form a system of „hypermedia documents“.
- creating own WWW documents and posting them, so either a closed group or the public Internet audience can access them.

It is neither my goal in this presentation to go into the technicalities of the transfer processes, nor of how to create WWW documents, nor of how to retrieve them to your own WWW „client station“ and browsing through them there. But on the functional basis descibed above I will investigate more deeply the possibilities of asynchronous communication for teaching/learning scenarios. Chapter 3 gives a selection of scenarios and their human communication properties, but with only few hints to the technical realization.

The easiest forms to organise are the closed learner groups on a homogenious technical platform (for example, a homogeneous local area network of PCs), but when the geographical distribution and the number of participants increases, it becomes rather improbable that such a homogenity can be enforced. If, for instance, one of communication partners is working in a network other than Internet (such as the commercial systems CompuServe and America Online or the private non-profit networks FidoNet or ComLink), then some of the functions may not be available and the partners will have to substitute them with another technical form, normally reducing therebye the ease of use.

As an example for a substitution process we can take group discussions. Such communication within closed or open groups can most easily be organized on the basis of newsgroups, which offer the functions of bulletin boards: if a person wants to contribute a text to a group discussion, then he has to select the bulletin board with the most appropriate topic label and post his message there. Anybody interested in that topic has to „walk to the board“ (access the newsgroup) in order to read all (new) postings. The initiative for retrieving information stays with the user, who, by the way, can thus control the transmission costs.

A bulletin board can be open to everybody, or restricted to a closed group, or its access is controlled by a moderator, who can moderate(i.e., filter, comment, or abbreviate) the messages. At present the Internet supports tenthousands of newsgroups, many of them only with regional distribution. The newsgroups relevant for schools and teaching are, for example, in the domains `k12.*` (for example `k12.lang.francais`), `school.*` and `schule.*`. These groups are not restricted.

If a group´s computing systems are fairly homogeneous, then special „groupware“ may be used. Normally this can be handled within well organised institutions such as private enterprises. There also exist some groupware systems, that can be installed on divergent computer platforms. At present efforts are undertaken to define common standards for the functionality of such software [ISO93], so one might hope for more interoperability. For schools such special software is not yet available.

3. Scenarios for telematics-based communication in education

In this chapter a few selected scenarios will be presented including reports of some experiences from schools, where telematics was integrated in teaching units. Since the scope of this article is the dicadctical design of software, I will only point out for the various scenarios, where special requirements for the functionality or for the user interfaces will have to be considered. (More details about the scenarios have been published in [Gorny/Sarnow 1993] and [Gorny 1995b].)

3.1 Scenario: Virtual classroom, virtual seminar

Communication attributes:	Partners: one teacher, many learners;
	Initiative: teacher;
	Main objective: knowledge transfer;
	Typical application: distant teaching.
Software requirements:	Standard telematics and presentation software, specialized groupware.

The normal teaching in school is organised in a classroom, where a group of pupils works together with one teacher on a certain subject. This situation is replicated in the "virtual classroom", except that it is not necessary any more to collect the participants at one place at the same time. This implies a change of the teacher's role:

- the transfer of knowledge from the teacher to the learners is still possible, but rather slow, so other telematics-based educational material could be used to enhance the knowledge transfer;
- the teacher's role as advisor, mentor and tutor is strengthened by the tool: the pupils can easily ask him directly without interfering with the group discussion, he can choose to submit such a question to the whole group or answer only to the pupil.

Software supporting this scenario reaches from normal email, including mailing lists and newsgroups to special groupware.

3.2 Scenario: Cooperation between virtual classrooms

Communication attributes:	Partners: several teachers, several learner groups;
	Initiative: teachers;
	Main objective: social contact; development of attitudes towards foreign cultures;
	Typical application: class partnerships.
Software requirements:	Standard telematics software plus specialized groupware.

By extending the first scenario (3.1) beyond the limits of one educational institution it reaches a new dimension: guided by their teachers the learners from geographically separated schools work on a specific topic. Knowledge transfer is more dominant again, since it can be expected that the preknowledge of the learners and the teachers' didactical approaches for the teaching differ widely. Examples for this approach can be found for the subjects geographie, civics, ecology, mathematics and biology. Very often also language teaching is included, when the schools are situated in different cultural areas. Examples are given in [Gorny/Sarnow 1993].

3.3 Scenario: Virtual project groups

Communication attributes:	Partners: one or several moderators, many participants;
	Initiative: all;
	Main objective: cooperative solution of an assignment, development of cooperation skills;
	Typical application: teaching/learning projects.
Software requirements:	Specialized (or standrard) telematics-based groupware.

You can imagine, that the step from the two first scenarios to project-organized learning is only very small. Telematics-based project groups can be organized on the basis of newsgroups or group mail technology. The frontal teaching of the traditional classroom has already been broken up in various threads of communication between the teacher and all pupils, the teacher and a single pupil and the pupils among each other. The teacher's role changes completely to a moderator and advisor.

Given a task and the possibility for self organisation pupils can work on large projects. This form is mostly practiced in upper secondary level classes and tertiary education.

Examples of telematics-based projects are presented more detailed in [Gorny/Sarnow 1993].

3.4 Scenario: Gathering material actively (via questionnaires etc.)

Communication attributes:	Partners: one teacher, many learners;
	Initiative: teacher;
	Main objective: opinion polls, knowledge acquisition from experts;
	Typical application: modern history and social ccience teaching.
Software requirements:	Standard telematics software.

This rather popular and easily implemented scenario can be used in almost all subjects. Students design a questionnaire on a specific topic and mail it to a known individuals or lists or post it in newsgroups. The incoming responses are collected and evaluated, and serve as a basis for further investigations of the topic.

It has also become popular, that students, for example, from a whole college class „publish“ their assignments in a news group or in the WWW and ask for comments from the public.

3.5 Scenario: Information search and dissemination

Communication attributes:	Partners: two or more teachers, two or more classes;
	Initiative: teachers;
	Main objective: information collection and retrieval, statistical evaluation;
	Typical application:science, mathematics, civics teaching.
Software requirements:	Standard telematics software, specialized database access software.

Besides the example AQUADATA already mentioned in scenario 3.3 we can mention a project between a German and a Spanish school for mathematics centering on statistics, programming, and sociology (common language: English). Both classes jointly designed a questionnaire directed to the other class respectively with questions about the pupils’ families (pupil's age, sex, brothers and sisters, weight and height, TV habits, parents' weight and height, parents' brothers and sisters etc.) The data collection phase was followed by an statistical evaluation including spread sheet and graph programming. These documents were also sent to the other school.

3.6 Scenario: Self-organised open learning

Communication attributes:	Partners: one or several learners;
	Initiative: learner;
	Main objective: retrieval of information stored previously by experts;
	Typical application: individual assignments with strong stress on reference literature.
Software requirements:	Specialized learning softwareware.

This scenario centers on individual activities of the learners while they are collecting information about a specific topic and during the structuring and evalulation of the gathered material, a process which is only possible when constructing new knowledge at the same time. The learners are encouraged to search on academic or journalistic information servers. The results may again be structured and stored in a local data base, so others can access them. The necessary technology is either Internet-based, or special software to access the information servers is needed.

For schools and university classes with direct on-line access to the Internet there another comfortable possibility: the WorldWideWeb. This fascinating technology allows the authors to link documents of various types together by setting interactive pointers (references) to other documents, thus creating hyper-media documents. The didactical objectives of this type of assignement are to develop information retrieval techniques, to evaluate and select relevant material from a vast choice of documents and to train computer handling by learning to program interactive documents with the WWW-language HTML (Hypertext Markup Language).

It is easily imaginable, that a student will be able to produce his assignments, or his thesis in this manner and present it in the WWW. In fact, several universities in the USA and in Europe practice this already.

4. Software Ergonomics – State of the Art in designing user interfaces for office work

4.1 Typical issues of Software Ergonomics

This presentation does not give the opportunity to describe Software Ergonomics in depth. It is the science of design and evaluation of user interfaces for software with respect to usability aspects of software. This implies that *users* have been assigned *tasks*, that have to be performed within the goals of the *organisation* for which they work, and that the tasks have to be performed with a computer as a *tool.*. The results of research in the area Human-Computer Interaction (HCI) and the related fields of cognitve psychology, informatics and graphics/industrial design are the foundation for software ergonomics.

It has to be stressed, that software ergonomics in the *narrow* sense does only deal with computer applications in work situations (fig. 3), but not with the design of computer games, or of software for advertising, leasure, learning, „edutainment“ and „infotainment“, though many of the research results can be transferred to these areas.

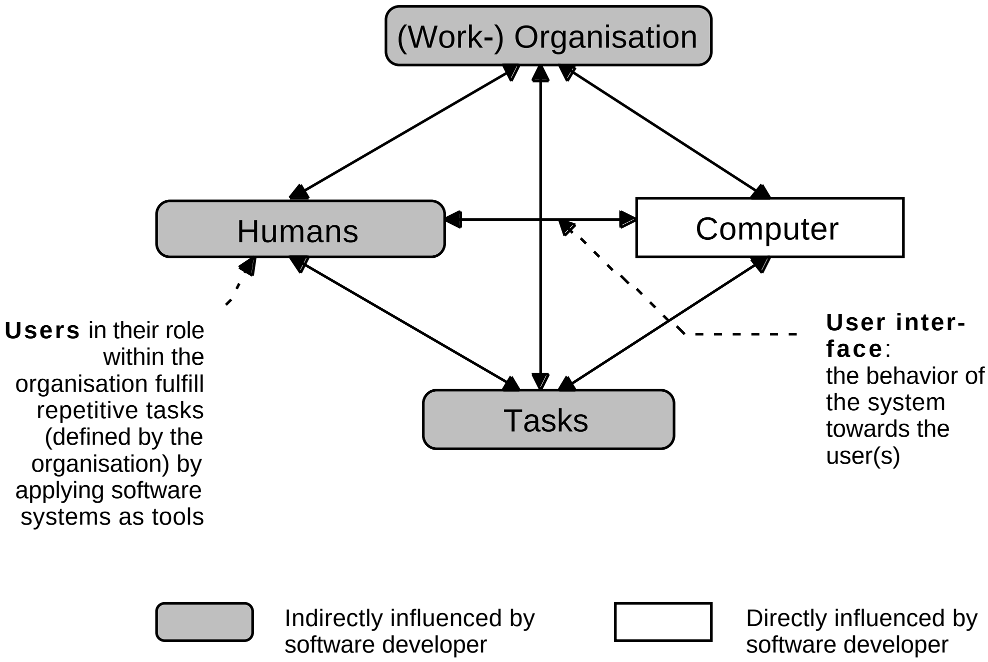


Fig. 3: Software-Ergonomics: usual work areas

4.2 Requirements and Recommendations for user interfaces

Software developers are subjected to various legal, half legal and informal requirements and long lists of recommendations. Besides the normal legal obligations (such as liability, copyright etc.) a new formal requirement has been developed: the minimum health requirements for work at displays, which the European Union issued in 1990 (EU directive 90/270/EEC), and which have become national law in most of the countries of the European Union. In connection with further regulations by national organisations software and hardware for office work has to comply with detailed descriptions of how a computer work place and the software are to be designed with respect to:

- hardware, furniture, illumination, climate in the office
- software

The directive uses expressions from ISO 9241, Part 10 – especially for task suitability, controllability, and adaptability. This standard has been developed in a coordinated effort between the International Standards Organisation, the Commission Européen de Normation (CEN) and several national standards organisations, so that ISO 9241 is identical (at least in the English version) with EN 9241, and DIN 29241. Of the few of the 17 parts of the standard that have been completed so far, we are mostly interested in Part 10: Dialog Principles:

The software has to be

- suited for fulfilling a specific task,
- selfdescriptive,
- conforming to user expectations,
- error tolerant,
- controllable by the user,
- adaptable to individual user needs,
- supportive for learning.

For each of the principles the standard gives definitions, recommendations and examples. Further of importance is the standard ISO 9241 - Part 11: Usability, presently in the state of a Draft Standard. It defines

usability = effectiveness + efficiency + user friendlyness

Additionally software developers have to cope with recommendations, called style guides, produced by software compagnies such as Apple, IBM, Microsoft or by other industrial cooperations such as OSF. With these style guides their respective authors try to help the developers in their design work in order to achieve a common „look and feel“ of the user interface. As we will show later, following these style guides is not sufficient to produce usable software in the sense of the European directive or the ISO principles.

4.3 Methodologies for designing user interfaces

Within the context of this paper we cannot discuss the various methods, which can be used for designing user interfaces complying with the requirements mentioned above. Therefore I will only present the method developed and used in my group: MUSE II – Method for User Interface Engineering [Gorny 1997]. This method forms the methodological background for the CASE tool EXPOSE [Gorny 1995a] and bases on

- the Activity Theory [Leontiev 1978],
- the Activity Regulation Theory, realized in the method KABA (Kontrastive Aufgabenanalyse) [Dunckel 1993], and
- the tool/material metaphor, which leads to an object-oriented design method for user interfaces [Daldrup 1996].

MUSE II structures the design process into three views

- conceptual view,
- interaction-oriented view,
- presentation-oriented view.

It allows to evaluates the user interface requirements in all three views from rules derived from work psychology, cognitive psychology, the standard ISO 9241 and the European directive 90/270/EEC. These rules link the analysis parameters to design decision parameters.

Following the method MUSE II the decision making for the design of software user interfaces involves:

- Specification of the tasks to be performed by the user,

- Specification of the objects used during the task performance (virtual objects, comparable with the real objects when working without computers) including the common user actions by which the objects are changed,
- Designing the software functions, which shall substitute
  + the user's actions on the real object (application functions),

  and additional software functions, which are used
  + to adapt the software to specific user requirements (adaption functions),
  + to control the computer system (control functions),
  + to support the usage by „help information", error messages etc. (meta functions),
- Designing the interaction between user and system,
- Designing the presentation of the virtual objects and the interaction objects.

5. Combining didactical and software-ergonomical approaches for software design

5.1 Designing educational software

To design educational software means – after the educational objectives (goals, contents,methods, and organisation) have been selected – designing the user interface to highest possible usability (Fig. 4). This can be done following MUSE II.

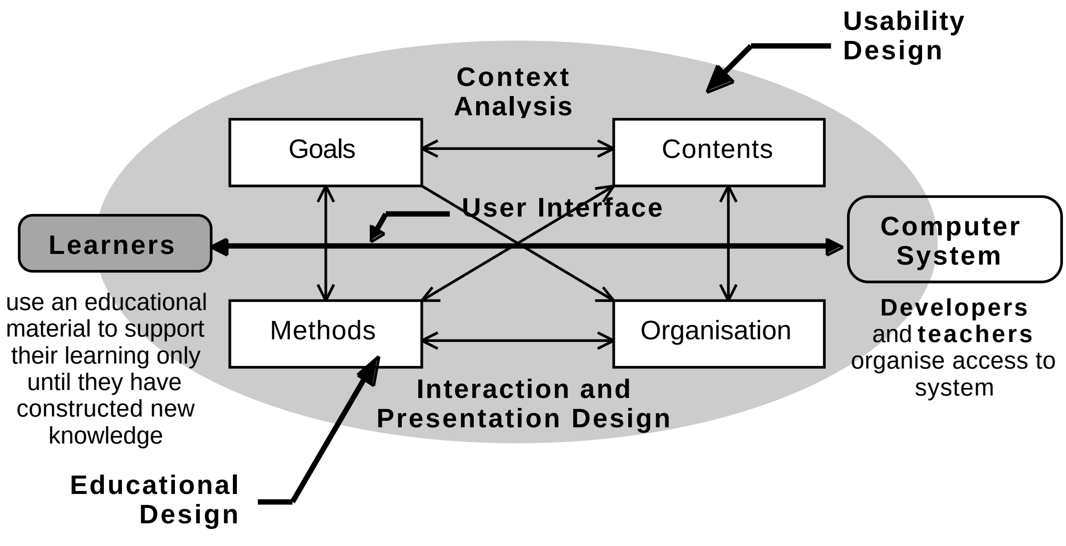


Fig. 4: Didactical design of educational software is educational design + usability design

5.2 MUSE II as a guide line for didactical design

The decision making for the didactical design following the method MUSE II can be described in these steps:

- Specification of goals, contents, methods and organisation for learning,

- Specification of the virtual objects used during the learning process,
- Designing the software functions, which substitute
  + the learner's actions on the real objects (application functions) and additional software functions, which are used ,
  + to allow the teacher to adapt the software to specific groups of learners and specific methodological and organisational conditions, and to adapt the software to individual learner requirements (adaption functions),
  + to control the computer system (control functions),
  + to support the usage by „help information“, warning and error messages etc. (meta functions),
- Designing the interaction between learner and system – taking the learner's level of experiences, and skills into account,
- Designing the presentation of the virtual objects and the interaction objects – taking the semiotics andaffordances of presentation forms into account.

„Affordance“ means the presentation of interaction objects according to the intended use, for example:

- button –> affords starting an action or function
- a menu item –> affords starting an action or function
- menu –> affords selecting one action or function from several (should not be used for parameter change)
- check box –> affords selection of one or several parameters of several
- radio button –> affords selection of exactly one parameter of several
- icon –> affords selecting an item representing a data object or a program
- tool bar –> affords selecting an action or function (should not be used for parameter change)
- text field –> affords input of text
- (scroll) list –> affords retrieving one text string from a list of text strings
- data field –> affords input of discrete numerical data
- slider –> should be used for input of continuous numerical data especially physical properties with measurement inaccuracy (time, length etc.)

The „semiotics“ imply the use of presentation methods, which comply with the content and semantics of the data. It is, for instance, not advisable to draw a line graph over a set of discrete values (e.g., number of items sold per annum in a sequence of years); instead a representation of the yearly sales in columns i suited. But to represent a time sequence of temperature measurements the line graph would the correct choice.

5.3 Didactical design for WWW-based educational software

When applying the learning model of constructivism as a gauge, e.g., to normal tutorial and training software, it becomes obvious that this software is not supporting teaching and learning effectively. Especially the advantages of the Internet cannot not be used. The possibilities for a learner to get support while he is attempting to gather information and construct new knowledge from it are greatest with simulation and modelling type software, and with role playing (see also [Thissen 1997]) with additional support by telematics-based communication and information retrieval. Following MUSE we will have to take following decisions:

- Specification of goals, contents, methods and organisation for learning

  Decision: self-organised open learning – preferably with the types of educational software:
  + problem-solving tools – modelling micro worlds
  + communication tools and -media
  + informations acquisition
  + simulations
  + role playing

- Specification of the virtual objects used during the learning process

- Designing the software functions (application functions, adaption functions, control functions, meta functions)

- Designing the interaction between learner and system, especially with Java-Applets, and keeping the interactiondesign on an appropriate level for the learner

- Designing the presentation using html, and multimedia documents
  + the presentation of interaction objects has to fulfill the principles selfdescriptiveness and conformity to user expectations (affordance)
  + the presentation of data objects has to confrom with the semantics of the data (semiotics)
    (It is noteworthy in this context that the present version of WWW, as defined in html 3 and in Java, still has severe drawbacks with respect to navigation, interaction techniques, and layout possibilities. Several software compagnies have attempted to mend these deficiencies, but it is still not advisable to apply features, that are not yet standardised.)

5.4 Example

In a printed document it is impossible to present the interactive features of the example. Therefore I will only present a rough outline of the learning with its didactical properties:

Interactive manipulation of graphed mathematical functions

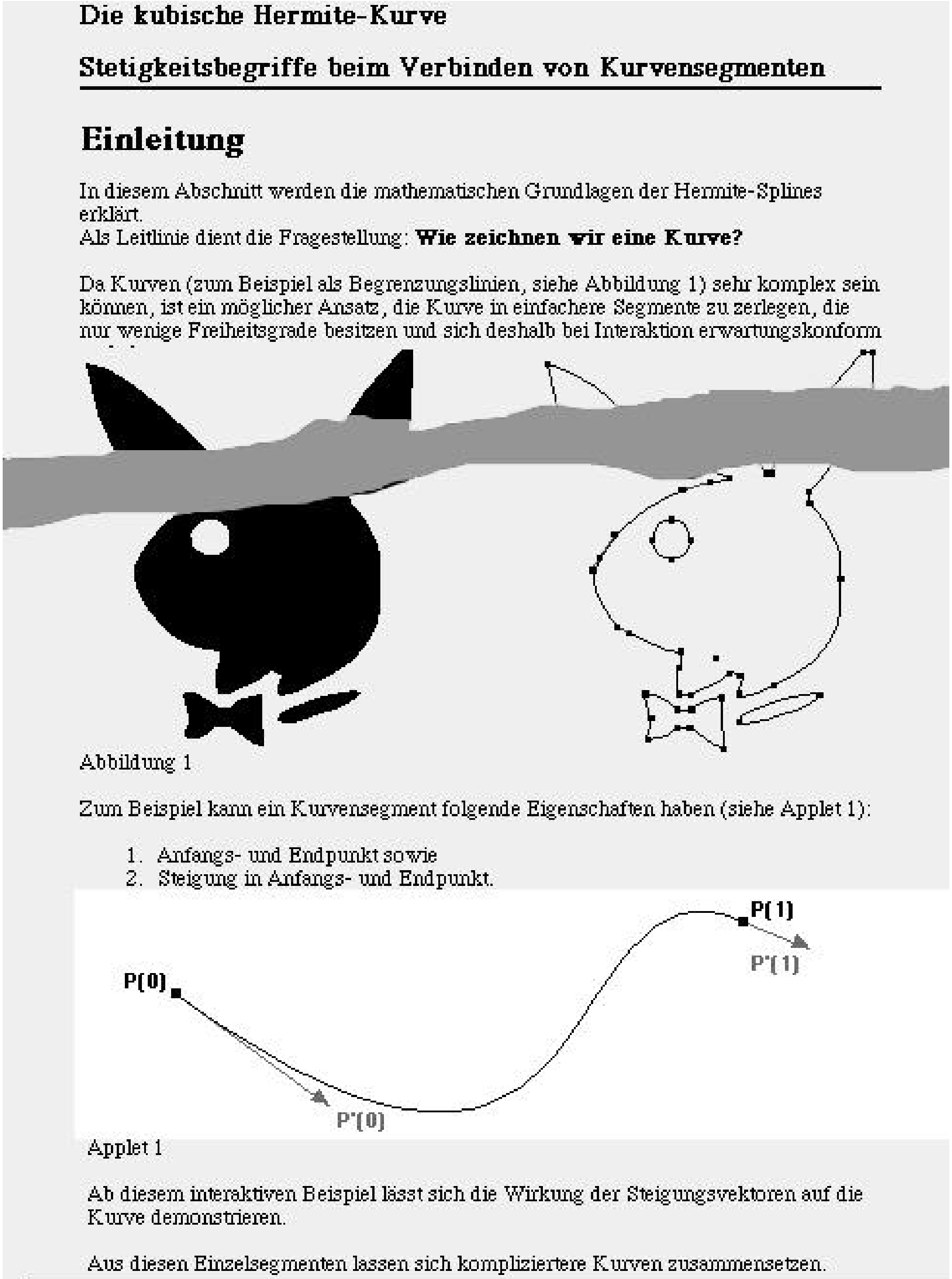
Type: Software for accompagnying college level lectures

Application area: Introduction to Generative Computer Graphics

The software is embedded into the lecture, which has these didactical properties:
- goal: to create scientific and practical competence in developing computer graphics software)
- content: ordered after scientific systematics,
- method: teacher presentation,
- organisation: frontal teaching.

Realization: interactive simulation software as Java applets, embedded in tutorial material with these didactical properties:
- goal: to enhance the understanding of interpolation and appoximation functions for producing graphics,
- content: interpolation and approximation in 2D and 3D with Hermite, Bezier and B-Spline functions,
- method: graphical presentation of start situation, interactive manipulation of curves or surfaces, tutorial type explanation of functions.
- organisation: self-organised individual learning (independantly from lecture)

The result in Fig. 5 shows only one of several Java applets, which allow to manipulate the graphics interactively. Instead also be a video or a graphics animation could be displayed. The surrounding text is not to be understood as an independent tutorial, but as part of the lecture material.



Die kubische Hermite-Kurve

Stetigkeitsbegriffe beim Verbinden von Kurvensegmenten

Einleitung

In diesem Abschnitt werden die mathematischen Grundlagen der Hermite-Splines erklärt.
Als Leitlinie dient die Fragestellung: **Wie zeichnen wir eine Kurve?**

Da Kurven (zum Beispiel als Begrenzungslinien, siehe Abbildung 1) sehr komplex sein können, ist ein möglicher Ansatz, die Kurve in einfachere Segmente zu zerlegen, die nur wenige Freiheitsgrade besitzen und sich deshalb bei Interaktion erwartungskonform

Abbildung 1

Zum Beispiel kann ein Kurvensegment folgende Eigenschaften haben (siehe Applet 1):

1. Anfangs- und Endpunkt sowie
2. Steigung in Anfangs- und Endpunkt.

Applet 1

Ab diesem interaktiven Beispiel lässt sich die Wirkung der Steigungsvektoren auf die Kurve demonstrieren.

Aus diesen Einzelsegmenten lassen sich kompliziertere Kurven zusammensetzen.

Fig. 5: Example for WWW-based educational software

The example has been developed within the preparatory project group for the project MuSIK (**M**edien-**u**nterstuetztes **S**tudium der **I**nformati**K** – media-supported computer science education), which will work on enhancing the teaching and learning of Computing Science at the University of Oldenburg during the period 1997-2000, mostly funded by the Federal Ministry of Education, Science, Research and Development and the Lower Saxony Ministry for Science and Culture.

The modules planned so far are topics from

- Introduction to Computing Science (datastructures - animation and modelling of algorithms, visualization of structures),

- Theoretical Computing Science (modelling of automata with various visual languages, i.e., state graphs and Petri nets, and testing by simulation),
- Software Engineering (modelling and simulation of project development processes, visualization of data structures, class hierarchies etc.)
- Operating Systems, Networks, and Information Systems (modelling, simulation of work loads),
- Applied Computing Science, for instance:
  + Computer Graphics (visualization of algorithms, interaction with graphics primitives, manipulating of color models, modelling of 3D-scenes including stereoscopics (VR))
  + Software Ergonomics and Human-Computer Interaction (modelling of user interfaces and interaction objects, color perecption etc., simulation of system behavior)
  + Image Processing and Pattern Recognition (Visualization of algorithms and interactive manipulation)
  + Intelligent Tutorial Systems and CBT (Modelling users, learning styles, tutor behavior etc., and visualizing the effects)
  + Applications of Information Technology in management, business, and adminstration, in production processes, in ecology, social science (modelling, simulation, visualization of structures)

The overall objectives of this project are

- enhancing present lectures in Computing Science education with interactive WWW-based material
- developing modules for open, self-organised learning, which will enable the faculty staff to reduce the lectures to those parts of the contents, that are especially suited for the methodological and organisational form of the lecture, while those parts suited for interactive manipulation of data will be presented in new modules.

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