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Reproduction of hypermedia lectures

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Abstract: Since 1994 the DIALECT project produces multimedia based lectures. An interdisciplinary production team together with university professors develops digital applications used in regular courses for pre-graduate students. Almost all team members can use our authoring and production environment, that has been designed to meet ambitious requirements upon design, didactical issues, contents and economic efficiency.

The first part of this paper discusses basic requirements and solution approaches from a more technical point of view. Part two summarises the results of a recently finished application called IRS. IRS consists mainly of high-resolution animation, featuring new concepts for presenting abstract and complex scientific content. Like previous DIALECT lectures IRS includes an interactive video storyline that illustrates the theory and acts as a content driven guided tour. DIALECT lectures have been utilised by hundreds of students and professionals so far.

Chapter 1: Introduction

The research project DIALECT started at the Freie Universität Berlin (free university of Berlin) in fall 1994. It produces digital interactive lectures, which employ modern multimedia technologies in order to significantly improve learning efficiency. The DIALECT lectures are available to students at the Free university and those at co-operating universities.

As high quality content has been top priority, significant efforts had to be made to accomplish the corresponding technological requirements. Development was directed to support learners and lecturers/authors. The lectures are part of regular courses and suited for preparation and repetition of taught matter afterwards. Digital interactive lectures do not depend on real time support by university staff.

Additionally to subject-related and didactic questions the DIALECT project also endeavours

economic development of teachware. This comprises development of a cost reducing, generic framework serving as a base for any content related reorientation.

Chapter two discusses common requirements to every DIALECT lecture. Chapter two also covers the redirection of DIALECT's distribution approach towards the world wide web. Further information concerning DIALECT, its infrastructure, general conditions, interdisciplinary teamdesign and didactic concepts can be obtained from [JENC7 96] and [ED-TELECOM 96]. Chapter three discusses highlights and concrete results from the most recent DIALECT lecture *IRS*.

Chapter 2: Building the lecture's framework

Necessities

It is not DIALECT's task to develop *new* multimedia technologies. This approach is continuous and stretches from particular media deployment (for example, codecs etc.) to distribution channels (for example, network protocols). Centre stage is the exploitation of *existing* free and commercial tools and technologies to the advantage of digital teachware.

As we refused to restrict the realisation of our concepts to a severe set of limitations from start, it was agreed to develop our own framework. This framework serves as a bone structure for new lectures to be implemented and provides for the following functionality and requirements.

Some important requirements to a DIALECT lecture

Didactics

Many students at our university have difficulties in applying theoretical concepts to empiric problems. Where applicable we therefore use a storyline or a case study to bring together 'dry' theoretical knowledge and 'stern' reality. The storyline is advanced in video scenes. By adjusting the story to the clichés and symbols of a specific genre, the user's *experience* with this genre can be invoked. Thus advantage is taken of his or her existing knowledge. Think of a man in a creased trenchcoat with his collar turned up and you will instantly surmise an investigating detective or something similar. See also Apostolopoulos et al. in [JENC7 96], p. 272-1 to 272-9 and Bielenberg/Carpenter-Smith in [ED-MEDIA 96], p. 57 - 62. This may help to stimulate a favourable user behaviour. This approach is also in line with the demands of the learning theory of constructionism, stating that a learning individual is no empty container at first which is to be filled with knowledge by the teacher (condensed in [Schulmeister 96], p. 67 - 71). Learning is rather a continuous *process*, in which the learner - building on his individual experience - constructs his or her own worlds of knowledge. A collection of explicit facts cannot sufficiently explain reality. Why should not individual socialisation be tapped as information resource (see also [Barret 95], p. 68)?

It is important, that users may choose individual paths through the knowledge space. This varying explorative behaviour is to be supported by the navigation concept of our applications (see below). If possible, knowledge presentation should be followed by active applications of the newly acquired matter by the user (for instance in simulations, computer based analysis, what-if calculations).

If the lecture is conceived to accompany conventional types of courses, it should take advantage of deliberate redundancy and demarcation. Content, relevant for examinations, should be included to improve acceptance of a lecture.

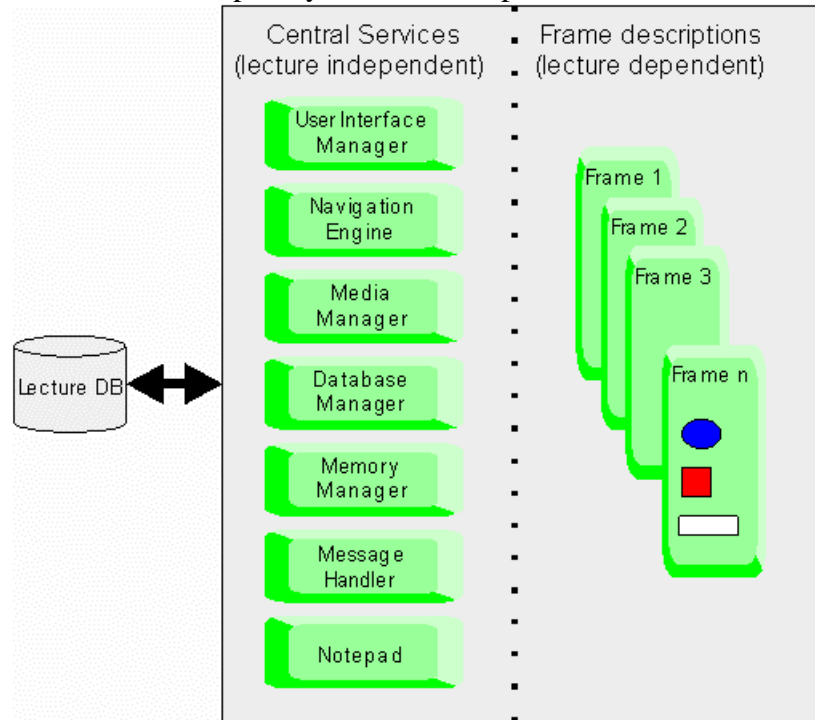
Navigation

Different individual approaches to learning entail individually different navigational behaviour of the users. The navigation manager should essentially provide for structured navigational models (i.e., linear, meshed, problem-oriented, discriminating) either at design time for the authors or at run time for users. At its highest level the navigation

manager allows the user to build his own navigational structures.

Modules of a DIALECT lecture

As illustrated below several conceptually different components have been developed:



Picture 1: Framework modules

To keep the system adaptable to contents of various kinds, the framework contains a lecture-independent central services component and a lecture-dependent frame descriptions component. As long as the fundamental requirements to navigation, didactical approach etc. mentioned-above remain essentially intact in the course of producing a new lecture, the central services components may stay unchanged.

The most important components are:

Navigation engine / lecture database

The navigation engine of the DIALECT framework fulfills two major tasks:

1. Providing an abstract description of each frame and its structural relation to other frames with respect to the construction of a knowledge space (sequence, hierarchy, mesh). Authors may choose one or several structuring types. The selected structures are exclusively stored and managed in the lecture database.
2. During each user session the navigation engine sustains the correct user inference (jumps, branching, guided tours) through the knowledge space. This data is also stored externally in the lecture database, alleviating maintenance.

Moreover the lecture database contains the complete management for all session-relevant media data.

The Frames

The screens where the information is actually located are called frames. They therefore represent the visible interface between author and learner. Starting from a coarse concept in a process of stepwise refinement the authors assemble the storyboards containing a complete description of the final frame. Those storyboards are then implemented by developers and layout professionals (concerning the production process, please refer to [JENC7 96], p. 272-5). Under perfect circumstances only frames have to be produced

while the framework with its central services remains unchanged.

Questions and experience related to actual implementation is covered in the next chapter three.

Distribution: DIALECT goes WWW

The world wide web evolves fast. Software manufacturers, scrambling for market share, now favour proprietary solutions for instance in the field of HTML-layout and authoring systems, database interfaces or component software (ActiveX vs. JavaBeans). However the purpose of these solutions is rarely to deliver an optimal solution for the customer but to strengthen their company's own product portfolios ('browser war'). At the same time new system architecture are established this way, often deliberately incompatible to those of other manufacturers. This undecided market situation prompts many developers to hesitate. It is perilous at the moment to make any long term strategic commitment to a development system in connection with the world wide web. Uncertainty over character and structure of future runtime environments as well as over the quality of network access aggravates the problem.

Nevertheless due to the expanded scope of web authoring and website management DIALECT will also have to make its decision on development platform and runtime environment for future DIALECT lectures. The first step was to evaluate, to which extent the current implementation of the DIALECT framework could use of the advantages of a world wide web based distribution concept. Please note that the current implementation is IP based but does not support HTML. This is an outcome of the framework's current requirement to access all media objects as DOS files. Such access via internet protocol could only be realised with NFS and the shortcomings of NFS in connection with continuous media are commonly known.

This level of abstraction was sufficient as long as the framework operated on the basis of local file access (CD-ROM, hard disk) or as long as a high performing intranet provider was available. Problems with 'Quality of Service' had to be addressed only conditionally in the past. The provision of media access via WWW required the expansion of the logical concept of an object towards the **media stream**. On the one hand this had technical reasons as, for example, the HTTP protocol per definition transfers data as a row oriented stream of bytes. On the other hand the usage mimic of DIALECT lectures posed certain demands. The highly interactive system expected an instant play reaction from continuous media (that is audio, video and animation). Longer waiting periods are simply not accepted by users. A complete distribution of DIALECT lectures via internet fails due to lacking guaranteed bandwidths and due to the widely differing quality of the multiple internet connections.

The framework would have to fulfill three major demands:

1. The media manager has to have the capability to retrieve data from URLs.
2. Data transfer must be possible via HTTP.
3. The presentation components of the user interface manager must also be able to render data *streams*, if possible with instant play functionality at least in connection with continuous media types.

Apart from the modified framework other problems arose:

- **New media formats**

Are the formats currently used by the DIALECT framework still the right choice? Are these formats at all capable of streaming? Do other formats exist, better suited to accomplish the stated tasks with respect to performance and playback quality?

- **Mediacaching**

Once an internet stream has downloaded completely, should it be permanently stored locally, in order to avoid repeated streaming? Or are established WWW caching procedures (proxy) sufficient?

- **Active media serving**

As distribution of continuous media challenges every network, an active server support of

the distribution process should be considered. Certain features stringently require active media servers.

New media formats

The following synopsis gives a summary of the media types and formats used in DIALECT lectures.

media type	media format	manufacturer of third-party addon software (if applicable)
(Hyper-)Text	TXM ATX	DBS GmbH Bennet-Tec Corp.
Raster graphics	BMP	
Spreadsheet	VTS	Visual Components Inc.
Business chart	VTC	Visual Components Inc.
Video	MPEG	
Animation	AVI (various codecs)	
Audio	WAV	

Among these formats there are some proprietary ones. This is due to the character of our development environment, which is based on Visual Basic®. If necessary, basic functionality is assumed by corresponding addon runtime libraries. These addons are mainly commercial product enhancements assigned to carry out special tasks within the framework (spreadsheet management). Even if these formats can be transferred via HTTP from a webserver, they often lack the instant play feature. With small-size media the resulting delay can be neglected. However if high resolution graphics are utilised, playback quality may be significantly diminished. This restriction can be eased only by choosing compressed formats.

It is much more interesting however to consider continuous types of media. During playback especially animation and video have to rely on efficient solutions for data transfer. Of course AVI, MPEG and WAV can, like other formats, be distributed using HTTP. But the key question is, what, if anything, sees the user, after the first few blocks have been transmitted. This depends on the media and file format. AVI marks an architecture that can incorporate any codec as long as certain interfaces are implemented. The separate codecs may apply very different approaches. Some codecs write certain index information to the end of their files. Such files definitely cannot implement instant play features. Unfortunately all previously used codecs belong to this category. An alternative had to be found.

We evaluated various file formats, e.g.:

RealMedia (Progressive Networks):

This format serves for presentation of audio and/or video, optimised for low and middle bandwidth data transfer (14.4 Kbit/s – 300 Kbit/s).

Flash (Macromedia):

The flash format serves to present 2D animation with synchronised audio. Flash animation is mainly vector based therefore requiring only low bandwidths.

Indeo 5 Progressive Download (Intel):

Indeo5 has a MPEG style encoding algorithm, but is also appropriate for the

display of animation. It trades relatively low scalable bandwidths for high demands to hardware performance.

NetShow (Microsoft):

NetShow serves for the display of audio and/or video data, optimised for low transfer rates. A range of different codecs is supported.

Of course, each format has its own advantages and restrictions. But as long as the background drivers are integrated into the operating system properly the lectures should utilise the best fitting file format.

Mediacaching

Deploying a web server as media provider implicates an additional problem: Once a stream has downloaded completely there should be an option to store it permanently in local storage. This would secure further use and prominently the future availability for high performance playback. However this feature depends particularly on support by format specific client software.

In principal the evolution of leading operation systems converges to this requirement. Microsoft for instance has increasingly incorporated multimedia components into recent releases of its operating systems. One of them (ActiveMovie) allows for the blockquoteect HTTP transfer of formats like MPEG and AVI and their motion presentation. For MPEGs, the instant play feature is implemented. Simultaneously a range of user interfaces (ActiveMovie player) and programming interfaces (ActiveMovie OCX) have been provided, assuring full programmatic control. But tests proved, that, for instance, the function saving to local hard disk is not programmaticable controlable.

Moreover employment of HTTP proxy servers can be considered. Proxy servers certainly offer advantages with respect to the exploitation of local resources to the maximum extent possible.

While the current chapter is devoted to the formal foundation of our framework and to the distribution approach, the next chapter discusses our concepts and experience with content-related issues like the particular restructuring of scientific content for presentation by multimedia techniques and the problem of interaction.

Chapter 3: Content redesign, demonstrated by the example of the DIALECT lecture 'IRS'

In order to realise the advantages of multimedia in teachware, the approach to content, the means of displaying it and the way in which it is lastingly acquired has to be changed. For the latter we also discuss some requirements in interactivity.

Two lasting problems reviewed

Display capacity

One of the key restrictions of digital teachware is that of CRT displays. The display capacity of a typical computer monitor equals that of one square inch clip of newspaper. This clip has a weight of 20 kilogramm attached to it and gets blanked out even by modest daylight. This should obviously prevent the use of longer text representations.

Nevertheless, extensive hypertext based expert systems have been developed for macroeconomics, physics and math. So far acceptance has been flaccid. Displaying contents in bookish style made up with multiple choice buttons is insufficient.

Verbal communication

Another severe restriction is the inability of teachware to implement at least a subset of verbal communication:

- The user cannot freely pose informal questions.
This deficit can to some extent be worked around by in-advance testing and discerning many possible questions users usually ask.
- The system cannot determine to what extent the user has understood a problem.
This is crucial, because explanations or tailored responses, even if they are available, cannot be given by the system as long as the system simply cannot know what exactly the user has not understood. Our approach to this problem has been, to test users, try to observe their misconceptions, and to design multiple-choice questions to trap exactly these misconceptions. Then the system may react appropriately.

IRS, the concrete lecture, demonstrating our approach

Content

IRS is a DIALECT lecture covering the impact of taxes on the classic investment calculus. First an extensive survey to the German tax system is given to motivate the model described. The model for investment contained in the lecture (the standard model for investment) is usually taught to students of business administration at the beginning of pre-graduate studies. The purpose of the lecture is to prepare the user for the examinations.

Target environment

It is intended, that the user can learn with the system alone or in tutored small groups. However the system can also be employed in classic types of teaching: lectures, seminars, exercises. The IRS lecture is finished and has been employed in courses since October 1997.

Didactics - Animation as medium of choice

First we thought of ways to squeeze the matter down to monitor size. As set out above, size and resolution simply do not suffice. But there is the time dimension. The display is updated and potentially changed seventy times per second. Animation appeared as the inevitable presentation form of choice.

But how to equip the timeline? Scrolling down the text and graphics of the original textbook?

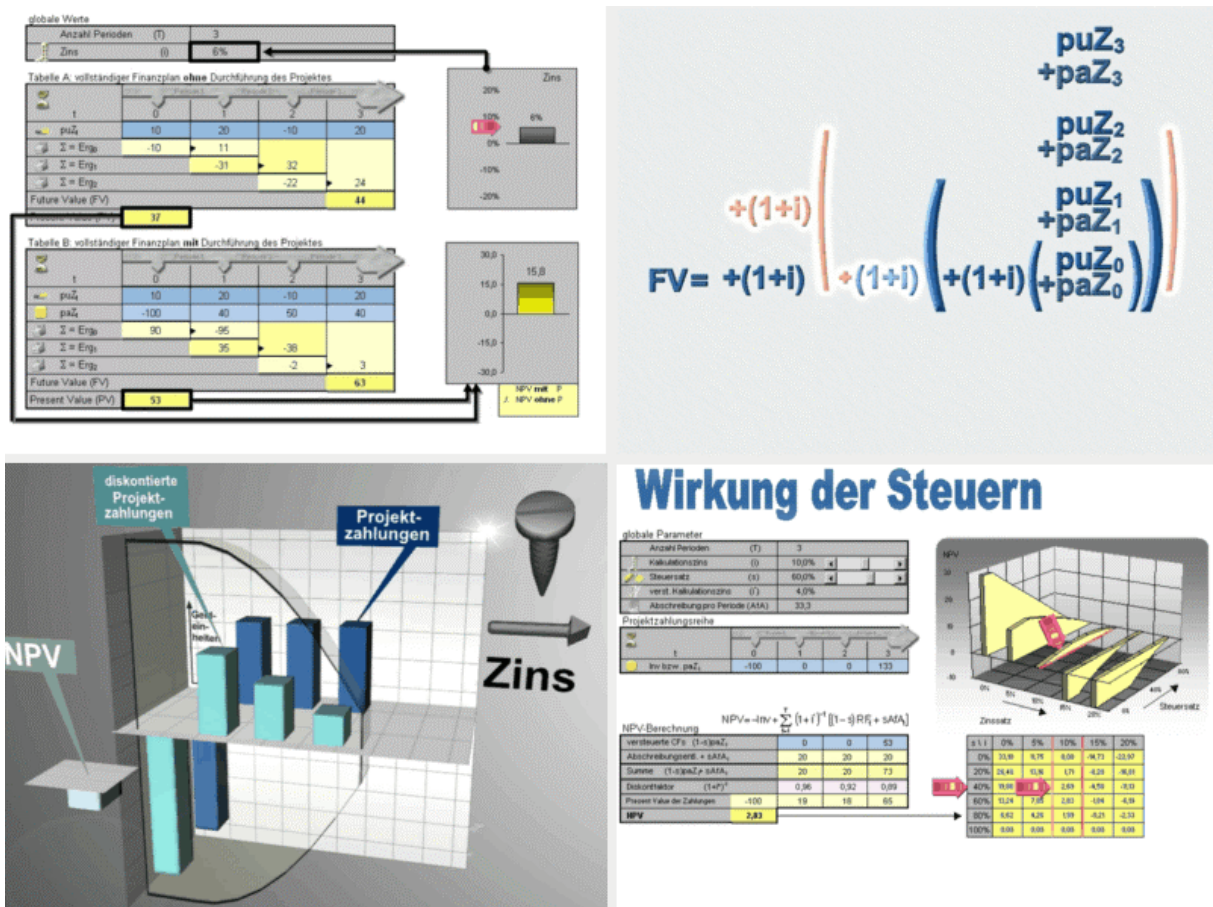
Didactics - Characteristics of content restructuring

- First one has to do away with classic styles of explanation. This is about compressing 80 pages of textbook into an all-comprising visual model.
- This model is assembled over a period time but it is not allowed to change its principle structure. The user should be able to recognise it during all stages of construction. And at the end of its evolution it must be possible to portray it in four or maximum six screenshots. The authors and designers have to concoct a visual structure that contains all elements mentioned on the 80 pages and that is capable of showing all associations that may exist between them. Associations have also to be presented in a qualified manner. Arrows will not do.
- The elements of the model must preferably be expressed with graphic symbols

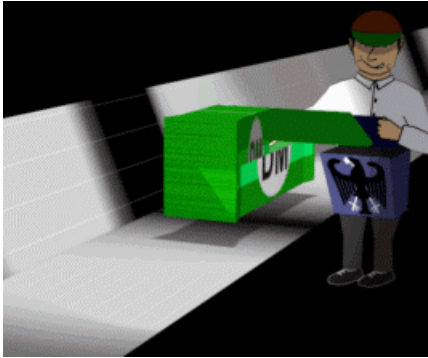
and metaphors since space is scarce.

- We decided to use three perspectives or modes on the model structure: one, that shows the elements as concrete numbers and a second that shows them as abstract symbols and metaphors. Certain conversions are properly accomplished in the symbolic mode. Then comprehension is enhanced by switching back to numbers. The structure remains the same. Complex quantitative interaction is best taught in the third mode: animated or interactive charts that represent numbers or metaphors. There the user may refine his understanding, of what grows when in which relation. Proper metaphoric representations may under certain circumstances realise an additional entertainment value.
- The visual model is developed or derived in high-resolution animation. A high framerate is not critical. Text explanations have to be substituted by audio. Our experience indicates that graphic and animation should be produced along a finished audio text.
- Imagination only starts to fly only if you are already in the process of producing. This holds particularly with the experts and authors.

For IRS we have realised such an animated visual model. The display size restriction could even be turned into an advantage, for an accomplished animated visual model supports the learning process far better than a textbook.



Picture 2: Perspectives to the core model of IRS: numbers, mathematical symbols, quantity chart and result (4 screenshots combined).



Picture 3: The act of levying a tax always catches attention.

Backing it up: Storyline and hypertext

After that a hypertext system may be incorporated. It also includes a glossary that holds all terms of general importance for taxes and investment.



Picture 4: Integrated hypertext components to supplement animation. Every graphic, spoken and written word of a frame is compiled in a RTF-file that can be accessed, partly or completely copied, annotated and exported.

Like every DIALECT lecture so far, IRS comes with a video storyline. Its essential purpose is to provide *situative* information to motivate knowledge. Therefore our storylines describe an application of theoretical concepts to reality. There he is, the protagonist who has to decide whether to invest or not. The users make extensive use of the storyline's function as navigational guideline. They typically watch one episode, then switch to the related contents and return afterwards for the next episode. In general users seem to prefer the application- or problem-oriented perspective. Thus storylines have potential.

A group of young friends start their career as employees in a blue-chip company. At first they encounter personal taxes. Then they get frustrated with the huge company's red tape and decide to found their own company. Having accomplished this, they encounter corporate taxes. Finally their flourishing enterprise comes under threat from their old employer. They have to consider a critical expansion investments, while having to pay taxes.



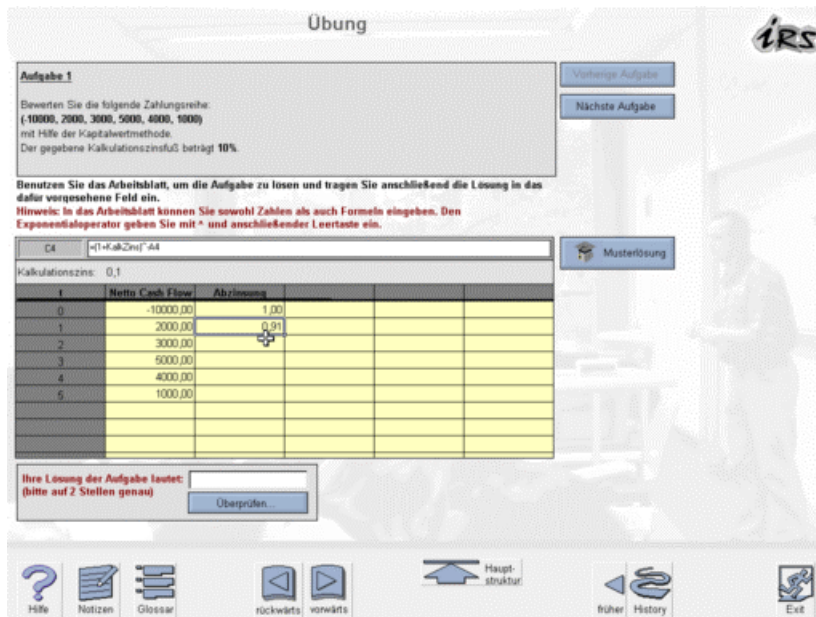
Picture 5: Storyline.

User-active components

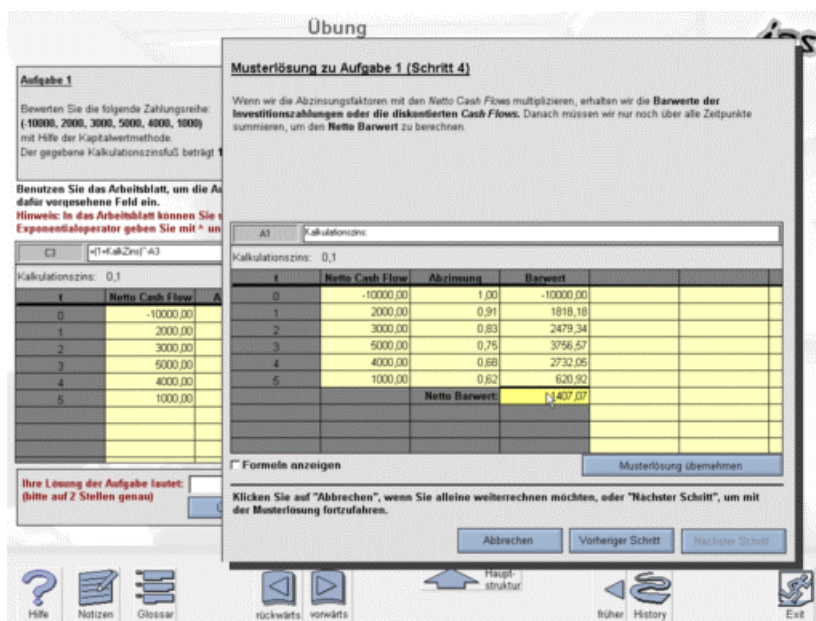
Numerous pedagogical and psychological essays and papers explain that learning is an *active* process. Even if you have indeed understood a solution, if you have never *actively* used it, you will soon forget it.

- The user has to *act; continuously* and *independently*.
The user must have tools at his disposal, to extract the problem, to derive a solution and to calculate this solution.
- The user must have support available at every stage and in gradual levels.
If the user does not get ahead, he cannot be left stuck until he helps himself. Help must be provided. All possible means have to be deployed to compensate for the lack of verbal communication.
- The user must be able to determine, whether he is right or not. He wants checks on his learning.

These features have been implemented in the exercise module of IRS. The user can choose from a number of different types of exercises. He can solve them in a spreadsheet workplace. If he does not know how to carry on, he may consult the step-by-step sample solution. If he is done, he tests his result. If he has made a systematic error, the system informs and he may correct it. Only those systematic errors are covered, which have been determined in pre-release user tests.



Picture 6: Exercise-frame. An exercise is situated in the area above, the spreadsheet workplace below. For each subject several types of exercises are included. The correct result can be tested in box below.



Picture 7: Exercise-frame. Each step towards the solution can be reviewed in the sample solution window.

The next DIALECT lecture will expand the current component into a full fledged statistics laboratory. We aspire to extend our existing spreadsheet-based workplace into a toolbox with symbolic objects and operators that can be applied to them.

Furthermore we see a large potential for serviced online forums via internet. Here the shortcomings of teachware in verbal communication should be further diminished.

Using the framework's flexibility

We had the necessity to play parts of several physical animation files like one logical animation. This was accomplished by extending the media manager with an abstraction layer. The low level MCI routines and the user-interface of the media-manager could be kept unchanged. We are looking forward to employ our framework-approach towards internet expansions.

One key achievement is that IRS consists mainly of animation. The spatial composition of all stages of the core model has to be premeditated and integrally planned.

Results and conclusions

Development based on a generic framework

- Productivity could be increased by about 50% compared to the first DIALECT lecture. Our estimate so far is 0.5 to 1 man months per 'hour of learning material'. The effort for video production tend to be overstated while efforts for animation are often underestimated.
- We do not yet have enough information for a long term evaluation of video employment. There is some evidence, that video proves exhausting if used too lavishly.
- Lectures have to be incorporated into the regular curriculum. The content of lectures has to be relevant in examinations.
- Authoring systems do not yet offer university personel a platform for the demanding requirements of complex contents.
- Operating systems increasingly integrate multimedia functionality into their core. However, we estimate that it will take approximately two further years until these features can be considered commodities.
- Evaluation designs that can claim to be objective and sufficient for generalising statements are not yet available for the area of teachware. Stable test environment cannot be guaranteed. Past statements have to be put into perspective. The manifold dependencies on the particular context complicate this task.

Using animation

- Descriptive, text-based explanations have to be restructured into animated visual models.
- In advance application-wide metaphors and symbols for the elements of the models have to be conceived. Their realisation requires a lot of creative graphics and (sub-)animation.
- Deliberate use of redundancy and repetition. Simple, illustrative, graphic, clear language.

Consequent compensation for the deficit in verbal communication

In advance testing of typical user questions and user misconceptions has to be planned and sufficiently funded. Allowances have to be made for significant changes and expansions to incorporate the results into the system.

User-active Components

Components, that allow the user to *actively* apply concepts with a maximum degree of freedom.

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HTTP-Links:

homepage of the DIALECT project: <http://www.wiwiss.fu-berlin.de/dialect>

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