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Concept and Realization of a Multimedia Program for Veterinary Physiology

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With 6 figures and 1 table

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Summary

A multimedia program, a non-linear system which supplements the traditional, linear way of learning (e.g. with a text book), was developed. Non-linear systems allow the direct use of information in a free sequence. A problem of these systems is the danger that the reader becomes lost in detail. Therefore, a program was constructed which tries to combine the properties of linear and non-linear teaching systems. Student groups were continuously involved during all stages of the project.The program is organized in several levels. These are: (1) choice of chapters; (2) table of contents of one chapter; (3) summary; (4) text and (5) pictures, animations, simulations and video sequences. The program can be used in different ways. In the linear mode, the reader selects via action words different levels of the program. The user can read either only on the level of the summaries or on detailed information (text, pictures, simulations and videos). In the non-linear mode the user jumps via menu items or buttons to selected pictures, simulations or a searched term. In this way, more than 3500 screen pages are integrated into a multimedia program for veterinary physiology. The program is written in TOOLBOOK®, and can be used on a personal computer with Windows 95® or higher.

Introduction

In the usual courses for the training of veterinary or human medicine, students are confronted with acquiring a growing amount of information in a limited time. Novel techniques are therefore necessary, which can support the traditional means of learning and teaching, such as text books or lectures, in order to deal with this challenge and to improve the success of learning (Goldberg and McKhann, 2000). Against this background, at the Institute of Veterinary Physiology of the University of Gießen, Germany a multimedia program was developed for use in veterinary physiology.

This program offers alternative modes for presenting the contents of physiological courses. The traditional, linear way of presenting information is supplemented by a non-linear system. A typical example for a linear learning system is a text book, in which the reader works step by step, from one chapter to the next. The unquestionable advantage of these linear systems is that the knowledge is presented in a systematic way, i.e. each chapter is based on the knowledge presented in the preceding chapters. However, linear systems soon reach their limits, if the reader searches quickly for an information, such as data about the pathophysiological background of a disease, e.g. diabetes mellitus, in which the user does not want to read the complete chapter about the pancreas, before a description of the function of the B cell responsible for the secretion of insulin is found.

A completely different mode of operation underlie non-linear systems (Volpe et al., 1998). Here, the reader can obtain any information in any sequence. A well-known example is the Internet, in which the user jumps via links from one topic to the next. Non-linear systems allow the fast access to any information available in the individual program. However, the obvious disadvantage of these systems is that after a short time the user runs the risk of losing orientations bearing in the amount of information found, which makes it difficult to discriminate between relevant and less important data. Therefore, a combination of the properties of linear and non-linear systems seems to be advantageous (Wiemer, 1998), which allows both types of operation depending on the individual demand.

Materials and Methods

Hardware: personal computer (pentium processor with at least 300 MHz) running under Windows 95®, Windows 98®, Windows 2000® (administrator rights necessary), or Windows NT 4.0® (administrator rights necessary) equipped with a fast video card (AV Master™, Fast Multimedia, Munich, Germany).

Multimedia language: TOOLBOOK® version 8.0 (Click2learn.com, Bellevue, WA, USA).

Word processing program: Word® (Microsoft, Redmond, WA, USA).

Graphic program: Freelance® (Lotus, Staines, UK).

To program simulations: VISUAL BASIC® (Microsoft, Redmond, WA) and TURBOC® (Borland, Scotts Valley, CA, USA).

Video producing program: Mediastudio Pro™ (Ulead, Taipei, Taiwan).

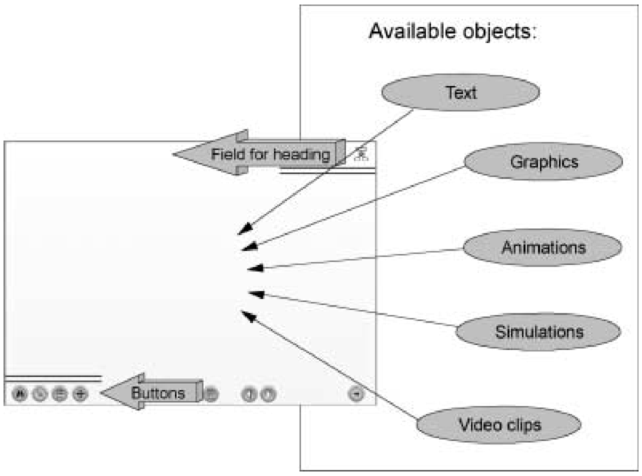


Fig. 1. Structure of a background page and the objects, which can be copied into a background page.

Concept of the program

In an initial phase, it took 6 months for the main structure of the program to be developed. Using one chapter of the main lecture, in this case the chapter 'autonomic nervous system', the principal architecture of the program (see below) was constructed using the multimedia language TOOLBOOK®. During this time, the code was developed for the main features of the program, although numerous changes in the program code were implemented during all subsequent phases, especially based on the discussion with students involved in the realization of the project.

The structure of multimedia programs, in general, has some similarities to that of books. One file (or book) is composed of a collection of individual (screen) pages with a navigation from one page to another. In the realized program, each chapter of the physiological course is organized as one file. As it was intended to involve student groups during the incorporation of the physiological contents into the program, it seemed necessary to create facilities that allow data to be filled, without detailed knowledge about programming techniques. Therefore, the so-called background pages were constructed, one for text and one for pictures (Fig. 1). These backgrounds contain the buttons[1] and menu items necessary for navigation across the final program. Into these background pages, different objects such as text, graphics, animations, simulations or video clips can be copied (Fig. 1). The objective of including these contents was to create an entity with defined properties (Morris, 2000; Steinmetz, 2000), e.g. the capability to respond to a mouse click.

Student groups

After developing the concept of the program, student groups were involved in further realization of the project, which took 4 years, i.e. four courses of students, who passed the physiological training during their second year of veterinary studies. About 10–20 second-year students (from a total number of 210) participated annually. In order to engage students, the idea of developing a multimedia program was presented in the main lecture and they were questioned about their interest to participate in the project on a strictly voluntary basis[2]. These students had a 2-h session with the authors every 2 weeks. During the initial sessions, they learned the principal basis of the multimedia language. For example, they learned the main commands and the syntax used in TOOLBOOK®. After about three to four sessions, they were divided into small groups of two or three persons, who were responsible for one chapter of the teaching material, e.g. 'cell physiology', 'neurophysiology', etc. They obtained text and pictures in electronic form, that had been developed by the authors for lectures on conventional text and graphic processing programs. Following this, the students had to connect the individual text blocks by hyperlinks and place the pictures in adequate positions in the text blocks. Owing to the more-or-less automatized buttons on a page, looking into the programming code was not needed. To fill the background pages with data, the students had free access to a computer in the institute at any time. The regular sessions every 2 weeks were then shifted to discussions about the content of the individual chapter and details about the best way of presentation, which, if accepted, were then built in the main programming code by the authors.

After about 2 years, the content of the main lecture was incorporated completely in this way into a multimedia program. In the following two courses, the topic of the seminar shifted to video techniques. The students learned to use a video camera, digital cut techniques and processing of images. As groups of three, the students filmed small parts of the practical exercises in physiology. Each group had to develop a concept for a short video clip (not exceeding 3–4 min), presenting the key message of each physiological exercise.

Result

The final program had the following properties (Table 1). It is an object-oriented multimedia program, i.e. it is composed of

[1]All buttons possess a program code making them (as much as possible) independent from the current position of the page in the program. For example, the button 'next summary' does not contain a physical link to a specific page, but instead it contains a script, which actually searches for the next summary page. Consequently, if a new summary is inserted, the previous summary will automatically detect this inserted page. All buttons are permanently present on a page, but depending on the position of a page, not all are shown. For example, the button 'this chapter is finished – choose the next chapter' is in most cases hidden, and only when no other page follows the presented page, the button becomes visible.

[2]Owing to a change in the legal regulation of the study of veterinary medicine ('Approbationsordnung') in Germany, beginning from October 2001 the conditions for participation at the multimedia seminar have changed. Until now, only courses, on which all students participated, were obligatory. With the new law, in addition to the obligatory courses, the students have to subscribe to a certain number of courses, which they can more or less freely select, until they have reached a certain sum of course hours. The multimedia seminar in physiology is one of the courses, in which they can accumulate these hours.

Table 1. General properties of the multimedia program for veterinary physiology

Aim	Realization
Hierarchical structure	Tree structure
Linear mode of learning	Action words, buttons
Self-directed learning	Menu items
Computer-based training	Collection of questions

independent objects, which function irrespective of each other and can be combined freely. For example, clicking on a detail of graphic will show a new, detailed picture, which will delete itself automatically, when the user does anything else. Therefore, each object has to be present only once in the program. The program is controlled by events, i.e. it reacts on pressing buttons, choosing a menu item, use of the cursor, or even the 'event' of doing nothing for longer than 10 s. The program is organized as an open system (see e.g. Graeber and Feldmann, 1998) for the development of an open system for teaching medical informatics). This means that from the main platform, i.e. the multimedia language TOOLBOOK®, any other Windows® program can be started, e.g. conventional computer languages such as VISUAL BASIC® or TURBOC® used to develop simulations of physiological processes, or viewers to present video movies. This open system allows the permanent evolution of the program.

The structure of the program follows a typical tree architecture with several levels arranged in a hierarchical way (Fig. 2). The uppermost layer is the choice of chapters. The chapters are arranged in the sequence of the main lecture, held 4 h per week over a period of 1 year. Each chapter possesses a table of contents, similar to a book. If a topic is selected from this, the third level (summaries) is reached. Here the relevant key words for a topic and their definitions are given here. From single key words, which function as action words, the reader can move to the fourth level (detailed text). From this level, action words lead to pictures, animations, simulations or video sequences.

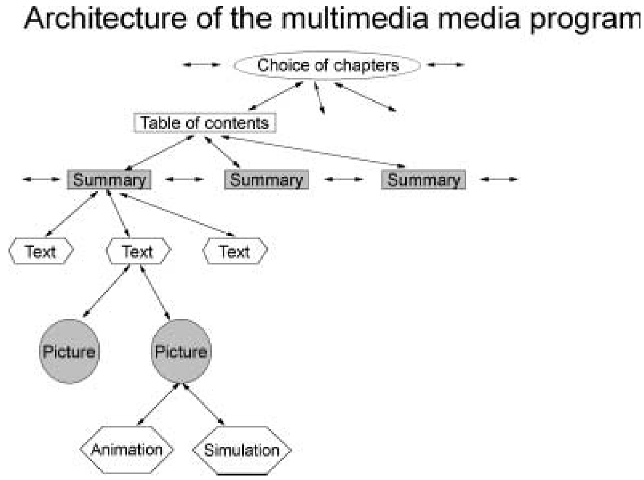


Fig. 2. General architecture of the multimedia program.

A typical screen print of a summary page is given in Fig. 3. It contains highlighted text, in this case in red, indicating the action words, which upon clicking will lead via hyperlinks to detailed text. The level indicator, i.e. the red bar in the middle of the symbol located in the upper right corner, indicates the layer – in this case the summaries – at which the reader is. Buttons at the bottom of the page allow navigation across the material. At the level of the pictures incorporation of short video clips with histological sections of the organs under consideration allows to link knowledge from different fields, i.e. morphology and function. In addition, animations, i.e. fixed sequences of pictures or illustrations with moving objects (similar to an animated cartoon), which do not allow the user to interact, can be programmed simply by moving or modifying single objects of a drawing. An example can be viewed at http://www.uni-giessen.de/fb18/vet-physiologie/homepage.htm when selecting the topic 'multimedia' followed by a click on the term 'animations'.

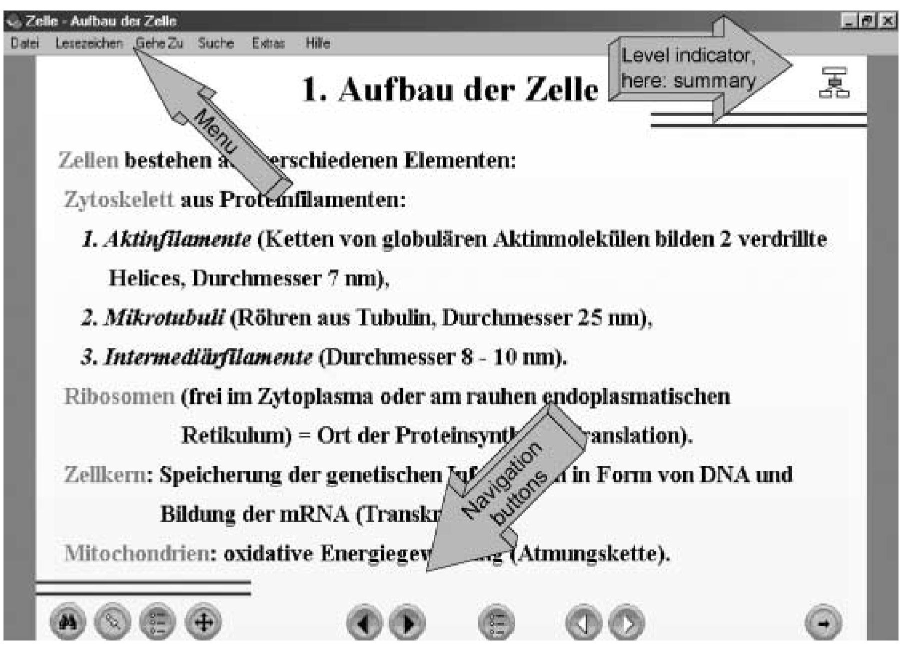


Fig. 3. Screen print of a text page containing a summary to the topic 'general structure of cells'.

Another way to consolidate physiological knowledge are simulations. In simulations, physiological processes, e.g. the changes in the potential at a recording electrode during an electrocardiogram, are calculated using mathematical formulae. In contrast to animations, they allow the user to modify parameters interactively. For example, it is possible to modify the heart axis and look at changes in the resulting electrocardiogram or to change the concentration of an ion in the extracellular medium and investigate the resulting alteration in membrane potential. In general, it is not very convenient to develop simulations with multimedia languages, which often do not contain all necessary mathematical functions. Therefore, the simulations, which have been incorporated, are written in conventional programming languages such as VISUAL BASIC® or TURBOC®, which – because of the properties of an open system – can simply be started by pressing on buttons in the main multimedia program.

The program can be used in different manners. In the regular, linear way the user moves via action words or buttons to the individual levels of the program. The user can either read all parts or can select only one level, e.g. read only the summaries, only the detailed text or take a look only at the pictures or the simulations. In order to avoid the risk of 'becoming lost', the program works in such a way that the reader always returns to the summary page, from which a change to the next topic is possible when using the program in the linear mode (Fig. 2).

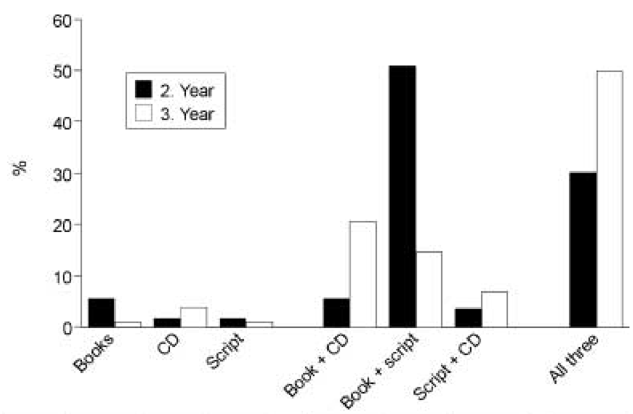
In the non-linear mode, the user jumps via menu items or the keyboard cursors to selected pictures, simulations or the desired level of the program. Integrated in the program is a differentiated search function. Items can either be searched exclusively in the chapter, in which the reader is at the moment, so that he will not, e.g. jump to the heart when he looks for 'action potential' in the chapter 'neurophysiology'. Items can be looked for exclusively in the summaries, so that the probability is high that the information found is of some significance. The last option of the search function is the free search in the complete text (summaries and detailed text) of all chapters. A database containing more than 3000 terms from physiology acts as a help file, because the users working in the non-linear mode of the program will soon be confronted with terms not familiar to them.

A fundamental problem during non-linear learning is the risk to lose orientations bearings. For example, the reader who wants to learn about the function of cholesterol when studying the structure of the cell membrane in the chapter 'cell physiology', can soon end at the production of bile acids in the liver, when he uses the free search function. Therefore, it is necessary to incorporate orientation facilities into multimedia learning programs. We tried to build in several of them. One is a heading above the menu bar, which shows – for each individual page – the topic being considered (see e.g. Fig. 3; upper left corner of the blue bar above the menu bar). A progress indicator demonstrates, which part (in percent) of the chapter has been already read. Further tools are a book mark or an individual note pad, which allows to copy own text or own pictures into the program and which has been recognized as meaningful supplementation to multimedia applications (Goldberg and McKhann, 2000).

Self-directed learning, i.e. learning in a sequence determined by the user (Morris, 2000; Steinmetz, 2000) is only meaningful, if the reader has the possibility to check the acquired knowledge. Modern multimedia languages, in general, contain pre-formed objects to be filled with specialized questions for computer-based training, i.e. for the autonomous control of the acquired knowledge (Morris, 2000; Steinmetz, 2000). This does not only include multiple choice questions, but also graphically organized questions, in which the user has to write a legend to a picture or to put individual metabolites of a biochemical reaction in the correct sequence. Two modes were incorporated for the use of questions in our program, a trial mode and an examination mode. In the trial mode, it is possible to return via links to the learning texts before the question is answered, whereas in the examination mode these links are turned off.

Evaluation by students

Two populations of students were evaluated using questionnaires: one population in the third year of study in veterinary medicine had already passed their examination in physiology, and another in the second year were still undergoing training in physiology (courses, seminars and lectures). Fifty-three students from the second and 102 students from the third year responded to the questionnaire. A total of 37 (70%) students of the second year knew the multimedia program, whereas in the third year it amounted to 98 (96%). When questioned about the kind of material they used to prepare the course in physiology, 20 students (38%) answered that they used the multimedia program, but the great majority used it in combination with other media such as books or scripts (Fig. 4). In contrast, when the students of the third year were asked about the material they used to prepare for the examination at the end of the second year, 62 (61%) of them replied that they used the multimedia program, again a huge majority used it in combination with other media (Fig. 4). Thus electronic media – at least in this population – seem to be quite well accepted for preparation of the examination, however, multimedia does not replace



Books	X			X	X		X
Cd		X		X		X	X
Script			X		X	X	X

Fig. 4. Answers of the second-year (black) and third-year (white) students. Students of the second year were questioned about the material used to prepare the course in physiology. Students of the third year were questioned about the material used to prepare the examination. All values are in percentage with 100 ($n = 53$) for the second year and $n = 102$ for the third year.

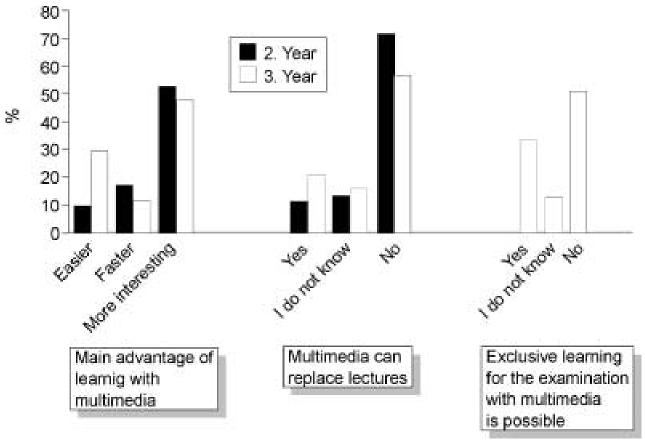


Fig. 5. Answers of second-year (black) and third-year (white) students. Students of both years were asked about the main advantage of learning with multimedia (only one answer was allowed; left group), and whether they believe that multimedia programs can replace lectures (middle group). Students of the third year were, in addition, questioned whether they believe that a preparation exclusively with a multimedia program would be sufficient for the examination in physiology (right group). All values are in percentage with 100 ($n = 53$) for the second year and $n = 102$ for the third year.

conventional methods of learning, but serves as a supplement for print media.

When questioned about the main advantage of multimedia programs in teaching, the majority of both populations had the opinion that learning gets more interesting (Fig. 5). Only a minority had the impression that learning might get faster or easier with electronic media. The majority did not believe that multimedia programs can replace conventional lectures or would be sufficient for the preparation of the examination (Fig. 5). Consequently, there is still an incomplete acceptance of multimedia material for teaching in universities (Blumenstyk, 2001). A separate evaluation was not performed on those students, who had participated in the multimedia seminars and were thus directly engaged in the process of developing the program. This might have been interesting in light of the question, whether such an engagement improves their abilities in physiology. However, as demonstrated in Fig. 4, most students (and thus probably also those directly involved in the project) use several sources of information (books, scripts, lecture, multimedia) for preparing the examination, which would make it quite difficult to elaborate the effect of the individual resources on the final test score[3].

Comparison with other developments

The program developed is far from being unique in the field. There are many related developments in physiology, ranging from more or less classical text book pages presented in the internet in pdf format (see e.g. DeFelice, 2001) to interactively organized courses with many links within the course itself or to external programs, e.g. to view the three-dimensional structure of a protein (see e.g. White, 2001). Most of them use similar structures as in the program presented here, i.e. they start with a choice of chapters, which allows a fast navigation within the material, and pages with detailed information containing text, pictures, animations, videos or multiple-choice questions; the whole then presented in the internet as html pages (see e.g. Godt, 2001; Nosek and Stoney, 2001). A difference of our program to these previous developments is a stronger subdivision in different levels, especially the consequent use of summaries before the reader reaches the detailed text, and the separation of text and picture/animation pages (Fig. 2). A faster orientation is expected from this organization, especially in the repetition phase of learning (e.g. just before an examination), i.e. the student can quickly move from one summary to the next and only go to the detailed text if he has no association to the data mentioned in the abstract (Fig. 2). However, a clear disadvantage of a multimedia language such as TOOLBOOK®, which was used to generate the current program, is that the pages, especially those containing programming code, cannot easily be converted into html pages for presenting in the internet.

A special feature of this project is the consequent involvement of student seminar groups during the development of the program. Co-operation with students has already been realized in other projects in the field. However, in these trials in general, small groups of students were engaged when performing their MD theses. Examples are the development of a program teaching cardiology (Projektgruppe Autodidakt, 1995; Friedl et al., 1996) at the University of Ulm, Germany (http://www.uni-ulm.de/uni/fak/zbmt/ua/didakt/home.html), a program concerning malaria from the University of Bern, Switzerland (http://www.aum.iawf.unibe.ch/VLZ/BWL/Malaria/Index.htm), or an ophthalmological project (Wassil et al., 1999) from the medical faculty of the university of Gießen (http://www.agma.med.uni-giessen.de/cfagma/lern/lern.dbm?Laufnummer=214). An advantage of the approach used in seminars, is the stronger multiplication of manpower and the direct feedback from the addressees, who intended to use the program for learning.

Conclusion

What is the benefit for students participating in such a multimedia seminar (Fig. 6)? These students acquire knowledge and abilities from different fields. They have to collect information about a topic, extract the relevant information and implement it into a multimedia resource to present it. They learn to work together in a group, e.g. by the common elaboration of the concept for a video clip. They have to discuss different ways of presentation of information, i.e. they have to compare several methods of learning and teaching. They also get trained in many computer programs. As a 'side-effect', they get very familiar with the chapter of physiology, in which they develop their individual project. The material developed in this way also affects the main curriculum of teaching physiology in our faculty. For example, simulations, e.g. the Goldman equation, were built in the course of physiology, when the membrane potential is taught. In the lecture, the pictures

[3]An evaluation of test scores was not tried on students working with the program and with those not using it. The reason is that the tests consist of oral examinations with each individual student. Consequently, such an evaluation would certainly create a bias in the results, if the examiner asks whether the student has used the teaching material developed by himself.

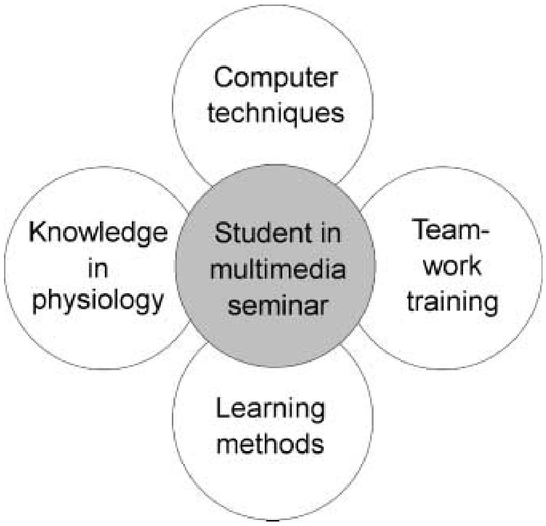


Fig. 6. Benefit for students participating in a multimedia seminar in physiology.

discussed with the student groups during the development of the multimedia program are presented as slide shows, i.e. as diagrams starting with only few information, in which the text or the picture grows together with what is being discussed during the lecture. These pictures are available on a learning CD for review at home. However, this is a good example that learning with multimedia facilities is a support (and not a complete substitute) for learning with conventional media (books, lectures), because it also turned out to be necessary for a printed version of the pictures to be presented in the lecture to the students, i.e. a classical script, in which the students can write their own notes during listening to the teacher.

This program is offered at the institute for the students at a cluster of computers, to which the students have free access. Alternatively, it can be obtained from a bookseller (ISBN 3-7773-14773) at low costs (less than 30euro). As the program was designed for the basic courses offered in the university (the second year of the veterinary training), it seemed advantageous to develop all texts in the mother language of the students, i.e. in German. Nevertheless, it is hoped that the experience gained with the development of this program and the unexpected enthusiasm of the student groups contributing to the elaboration of the teaching material can be the basis for similar developments in other fields.

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