

IT'S A LONG WAY TO MULTIMEDIA: AN ACCOUNT OF 18 YEARS OF PURSUING A NEW MEDIA PROJECT IN PHYSIOLOGY

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A teaching-oriented multimedia database authoring system, MILES (Multimediales Informations- und Lehrsystem), has been in development since 1980 in our department. The hardware consists of a network of personal computers connected to digital and, until recently, audio/video storage devices. The system provides a database capable of handling all kinds of multimedia data and computer programs. User-friendly software provides input, editing, retrieval, and communication; the authoring system allows these components to be organized into structures of complex menus, combined with free database access. More than 12,000 components have been stored, including ~3,500 pictures. The paper reports on an extensive field test, in which the system has been applied as a common source for all kinds of materials used in teaching physiology to students of medicine. Results show that the "new media" are powerful instruments for improving teaching and learning. However, they should not be expected to provide the sole basis for education. Their application still faces many problems regarding concepts, efficiency, and acceptance by students and staff.

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PROJECT HISTORY

The multimedia database authoring system MILES (Multimediales Informations- und Lehrsystem) is Germany's oldest still surviving "new media" project in physiology and medicine and has also been one of the most expensive ones. The system has been developed in the Department of Physiology, University of Essen Medical School, in two stages since 1980 (19), conceived (20) under the impact of visionary predictions at that time about the forthcoming role of new information technologies in education (2). Until then, only a film-guided practical in physiology (16) and a series of clinical computer-assisted learning (CAL) programs (12) had been produced in Germany in this

field. The aim of MILES was not to produce single CAL teaching units, such as particular simulations or tutorials, but a system providing all computer and audiovisual materials for teaching and studying physiology over the entire curriculum.

In retrospect, it becomes clear why the initial version of this system, named Studienmodell Physiologie (SMP), could then not reach its aims. The available system basis was the mainframe computer, which could not furnish storage for either large collections of pictures or video. Databases suitable for multimedia were not yet on the market, so this essential part of the software had to be developed anew. Bildschirm-text, the German version of teletext, which was then

expected to become the general high-speed mass communication system (but did not), was employed as a supraregional communication system. Furthermore, the project turned out to be understaffed, in regard to both physiologists, most of whom had to work out the materials in addition to their regular assignments in teaching and research, and programmers, who had to be hired separately on the basis of grants, because the department of biomathematics of the medical school as well as the computer center of the university claimed to be unable to take over, or even guide, the task. A particular burden resulted from the lack of components for composing teaching materials; the expert systems and databases for all kinds of data including pictures and films, predicted to soon make these teaching materials available in abundance, never appeared. Consequently, progress was slow.

In 1986, the test operation of the system in teaching began (18). In 1987, the first long-distance transfer of teaching material via satellite was carried out from our department in Essen to Beijing, China, highlighted by the first public video conference between two German university presidents and the president of Beijing University; the background noise of the enthusiastic throng in the Beijing presentation tent unfortunately made the conversation largely unintelligible. However, this first cry of the newborn system turned out to be the last; by that time, educational technology had already been revolutionized by the microcomputer, and systems employing mainframes were past use.

After 1986, the concept was transferred to the personal computer (21). The field test of this system, now called MILES/SMP, began during 1989–1991 in connection with the teaching of physiology to 160 students of medicine per year. Physiology as part of the preclinical medical curriculum—the minimum extent of classes as defined by federal decree for all German medical schools—comprises a two-semester lecture (4 hours per week), a one-semester physiological practical (8 hours), a one-semester seminar (2 hours), and a one-semester introductory clinical practical (2 hours, proportional share 0.5 hours). Since 1993, MILES has been employed increasingly in all types of classes as well as in individual studies independent of classes and has been presented at national as well as

international conferences (see Refs. 21–24, among others). By the fall of 1998, most of the curriculum subject matter furnished by the department was available in the system. In addition to this application in Essen (MILES/SMP), the system was tested temporarily with other respective materials in teaching computer science to students of economics [Studieninformationssystem Betriebliche Datenverarbeitung (MILES/SIB), Fachhochschule Dortmund, Dortmund, Germany, and University of Plymouth, Plymouth, UK; Ref. 6]; a third version [Datenanalyse Baugometrie des Mittelalters (MILES/DBM)] is employed in the study of art history in connection with research on building geometry of medieval churches (University of Essen, Essen, Germany; Fachhochschule Würzburg, Würzburg, Germany, and University of Pennsylvania, Philadelphia, PA; Refs. 25 and 26).

CONFIGURATION OF MILES

Hardware. The hardware consists of a network of personal computers (Pentium processor, SVGA 1,024 × 768; MS-DOS/Windows 95 operating system) supported by servers. Until recently, storage devices for audio/video have been video disk and tape; they are now being replaced by digital carriers (CD-ROM).

Software. The software is built around a text-processing database that provides access to all types of material. The database is combined with an authoring system. The latter is capable of 1) organizing the database, including subsets for applications in which only part of the material is to be made accessible; 2) assembling all types of data and programs, together with free access to defined sections of the database, into teaching units structured as menus of varying complexity; and 3) generating the text-based user interface with free definition of input fields on screen and with hypertext linkage to other documents as tools for structuring dialogue courseware.

The user is offered two modes for retrieval. First, the material can be selected from defined menus or input fields on screen. Second, the database can be accessed directly by free input of key words; both modes can be combined. Students also possess a personal base (Fig. 1, *bottom*) to which data and programs can be transferred by their references from the main system using a standard command.

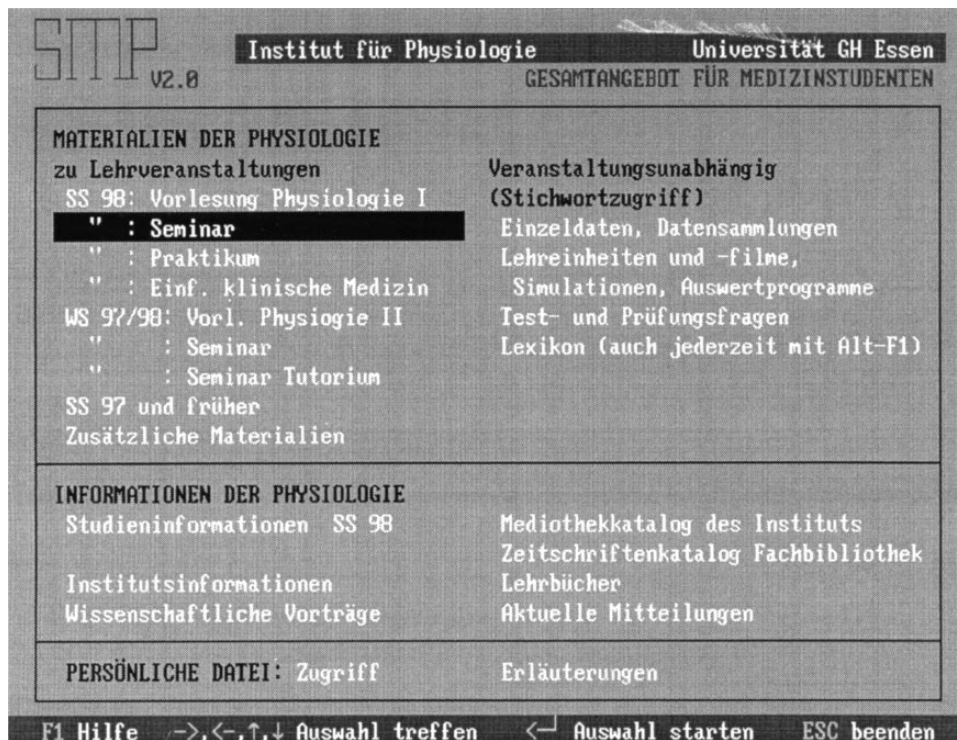


FIG. 1.

Entry screen for students using MILES/SMP. Top section: teaching materials (*left*, records from classes; *right*, free database access). Middle section: information. Bottom section: personal base.

ORGANIZATION OF MATERIALS

Archive. Except for large menus, such as documentation of entire lectures, materials are pooled in the database as documents. These are classified by key words with regard to subject matter (systematized in a thesaurus composed especially for physiology), type of data, title, author, source, and level of complexity, such as single data, data collections, or teaching modules. Many of these documents, such as the collection of test questions and the glossary, can be searched by full-text analysis.

Access. Access to teaching materials is provided for students in two ways. One path is organized according to classes and contains the demonstration and working materials treated there. This part is structured in menus differentiating the type (lecture, seminar, practical) and year (1998, 1997, and former years) of the respective class (Fig. 1, *upper left*). Because this means that the contents of not only current but also past classes remain documented, students can rework

the entire curriculum. The second path consists of free key word input accessing certain subsections of the database classified as single data, data collections, teaching modules, test questions, and glossary (Fig. 1, *upper right*). The level for staff extends that for students by allowing access to additional materials and functions. Thus the teacher can directly present in class any material, such as a figure from the "electronic slide collection," and prepare collections for demonstration that differ from those available to students. The system also provides information about the department (Fig. 1, *middle*). Information about MILES is also available on the Internet (<http://physio.medizin.uni-essen.de>).

Stock of materials. At present, more than 12,000 components have been stored as documents, including data processing programs, simulations, signal recordings, video and audio modules, ~3,500 pictures from textbooks and scientific literature, a glossary of physiology with several hundred entries, and a collec-

tion of ~4,000 test questions, which also cover years of the nationwide final exams. Most long films incorporated into the system were provided with a modular structure, permitting subunits to be called without the user having to go through the entire strip. Only part of the material was produced in the department and consists of programs for processing signal recordings and for image analysis (mainly employed for analysis of plans in MILES/DBM), biomedical recordings (speech sounds and neural activity, among others), simulations of impaired hearing (produced in 1984 as the first German video disk in physiology), and numerous text documents, such as lecture notes, instructions, commentaries, and most of the glossary and test questions. The other part comes from external sources. This includes most of the collection of pictures, drawn from figures in books and periodicals; programs for data processing obtained from other departments, e.g., Kiel (27) and Münster (1); most of the films; and the majority of simulations. These are mostly of Anglo-American origin, such as the Mac (9), Neurosim (7), and SimBioSys (14) programs, supplemented by the few German productions existing at the time, such as Neuro (11) and Virtual Physiology (17). Computer-assisted design (CAD) materials are not yet used in MILES/SMP but have been developed for the version of MILES/DBM.

INTEGRATION OF MATERIALS INTO TEACHING

Concept. As stated earlier, the aim of the project is the use of a multimedia system as a common source for all teaching materials provided by the department. The intention is not to achieve this generally by using extensive text-oriented programs, covering the subject matter in a manner analogous to the use of textbooks. Consequently, lectures are usually not documented literally in MILES via "multimedia lecture scripts." Students are, as before, expected to acquire their basic knowledge from textbooks, whereas MILES mainly covers complementary aspects and subject matter conveyed more effectively by computer and audiovisual techniques, with respective criteria differing, of course, between instructors.

Teaching units. The units compiled from the components described in **Stock of materials** are structured differently, depending on their curricular affiliation (lecture, seminar, or practical) and level of comprehensiveness required by their contents (e.g., whether

they treat new topics or just present supplements to matters generally available from textbooks). Except for the instruction book of the practical and the recently issued CD, these materials could not otherwise be handed out to students for the following reason: whereas publishers and producers of pictures and films, as the owners of copyrights for most of our audiovisual materials, tolerate the presentation of these materials on the electronic medium within the institute, they strictly forbid any outside transfer. Consequently, we also did not hand out the text sections, fearing this would induce students to neglect the multimedia sections available solely on departmental computers.

Demonstration in lectures and seminars. For demonstration, classrooms are equipped with projectors for computer and video; I have not used conventional slides in class for years. In the records for students, the topics treated in class are generally summarized by key words, if not explained in more detail by lecture notes, and the audiovisual and computer materials are presented again. Importance is especially attached to materials not available from textbooks, such as figures and tables from scientific literature. Wherever necessary, these materials are explained by text comments to make them understandable apart from the presentation in class. These records are then available in the computer rooms for individual studies.

Work in seminars and practicals. In seminars, working materials typically comprise simulations and recordings of laboratory data to be dealt with in class or as an additional assignment. For this work, seminar rooms are equipped with terminals. These materials also remain available in MILES. The physiological practical, guided by staff, is destined for the measurement of biologic functions in humans. Here, the emphasis of system application is placed on the acquisition and processing of biomedical data. Of 11 thematic units treated, 7 are directly supported by computer, including general introduction into physiological techniques; analyses of recordings of speech sounds, oculograms, reflexes, evoked potentials, and electrocardiograms; and simulations of membrane potential and nerve activity. MILES provides the proper programs for analysis of data to be recorded by

students themselves and to be drawn additionally from collections of typical signals furnished by the system. Along with experiments, complementary teaching units are offered for deepening the understanding of these topics. These units and the simulations are also available in the computer rooms.

Individual studies independent of classes. In the computer rooms students can work individually with the system. The main materials are the records of class teaching. In addition, materials are also offered—data, simulations, tutorials—for extending subject matter beyond classes. By using the above-described functions for setting up personal collections, users can select and organize these materials according to their own preferences.

Units for studies at home. The summer term of 1998 brought a breakthrough with the release of the first CD for use in home studies. This became possible because the leading German publishers finally gave permission to hand out their materials to students, but only for this one CD and only to students attending this class. This CD contains the documentation of the “speech” seminar comprising, in addition to the full text, 153 figures, several films and simulations, recordings of speech sounds with a program for on-line Fourier analysis, more than 300 test questions, and the entire glossary. It also offers the functions of text analysis and of setting up personal collections from these materials. This CD coincided with a significant change in the availability of home computers. Whereas in former years only a minority (increasing) of our students possessed such computers, they have now become standard for the freshman generation. At what pace, and on what carriers (i.e., Internet), further steps of MILES toward home studies will be possible is presently uncertain.

EXPERIENCES

System performance. Our expectations in regard to power, versatility, and portability of such “open” multimedia systems have been fully confirmed. The computer-based integration of materials of all kinds, from external as well as internal origin, into local individual teaching has proven to be most promising. Problems no longer arise from hardware, but they

TABLE 1
Results from student questionnaires for “speech” seminar

| Subject of Question | n | Rating | |
|--|-----|--------|---------------|
| | | Range | Mean \pm SD |
| Subject matter | | | |
| Attractiveness of topic | 1–5 | | 2.8 \pm 1.1 |
| Propriety of demands | 1–4 | | 2.3 \pm 0.8 |
| Relevance to medical education | 1–5 | | 3.2 \pm 1.2 |
| Teacher | | | |
| Quality of presentation | 1–5 | | 3.5 \pm 1.2 |
| Multimedia system MILES | | | |
| Extent of use | | | |
| High | 11 | | |
| Medium | 21 | | |
| Low | 11 | | |
| None | 1 | | |
| Quality of presentation of subject matter | 1–4 | | 2.4 \pm 0.8 |
| Quality of screen design | 1–4 | | 2.6 \pm 0.8 |
| Comfort of system operation | 1–5 | | 2.5 \pm 0.9 |
| General value of MILES for studying | 1–4 | | 2.2 \pm 1.0 |
| Availability of MILES materials for home study | 1–3 | | 1.5 \pm 0.7 |

Results are from questionnaires of 44 of 48 participants in the “speech” seminar for 1998 summer term. Work with MILES had not been obligatory in class. Of these students, 38 owned computers capable of running the seminar CD. Grades to be given ranged from 1 (excellent) to 2 (good), 3 (average), 4 (poor), or 5 (unsatisfactory). *n*, No. of answers.

arise instead from software maintenance, production of teaching material, and the uncertainty of application concepts (see below). Specific software problems for large systems such as MILES, advanced in years, result from the necessity to adjust to new operating systems and user interfaces, which is hard for small teams to accomplish. Thus, although MILES also employs Windows for imported programs, its main system still runs on DOS.

Acceptance by students. The system has, according to questionnaires, been accepted well by students. In the questionnaires about seminars (cf. Table 1), the first type of class covered completely by system materials, our students rated the quality of the presentation of subject matter in MILES even higher than that of the oral presentation (embarrassingly, my own). Notwithstanding, they considered the component of personal teaching as essential for such assignments, especially for providing the necessary panel for discus-

sions. The availability of materials for home studies on CD was unanimously praised as an important improvement. However, in practice, this positive attitude toward the new media held true only for materials from seminars and practicals, that is, from obligatory classes containing subject matter covered on exams thereafter; these examinations must be passed to qualify for admission to the final exams. Here, our students made intensive use of system materials, even if work with the system in class, as in certain seminars, was not generally obligatory. The interest was significantly less for materials from lectures, which comprise a problematic class that in Essen, as is traditional in Germany, is neither obligatory nor combined with examinations, conveying subject matter more relevant to the finals. However, because these are dominated by a nationwide written test that has no relation to the particulars of individual departments, students rightly consider preparation from textbooks as much more effective than from lectures. Consequently, the attendance for this type of class was already usually very low. Here, the philosophy of MILES to provide material mainly extending beyond the basic level of textbooks “clutched at thin air.” The acceptance was definitely poor when materials were offered as mere self-education programs for use in bypassing classes. Thus our special collections of extracurricular materials, selected and offered regularly on student terminals for additional voluntary work, suffered a fate well known from corresponding traditional film collections: they were largely ignored. Understandably, the only type of material enjoying undiminished general interest up to the time of final examinations was test questions, which also furnished most of the material transferred to personal bases.

Teaching results. We consider that teaching results, given the limitations described, are good, although this cannot be verified at present, because the staff situation in Essen does not allow the formation of control groups by setting up two lines of classes, one with and one without application of the system, and other procedures for evaluation have been beyond our abilities. Thus the slight improvement of our department in the ranking list of nationwide written examinations in the early 1990s cannot be counted as conclusive, because, along with the introduction of MILES, the standards of examinations in classes were raised, which surely caused our students to increase

their occupation with physiology. The counterpoint is the recent drop in the ranking list, despite the increase in multimedia teaching; this was probably caused by the mitigation of standards in the late 1990s. On the other hand, handing out the materials for the “speech” seminar on CD significantly improved the rate of passing for exams in this class, with requirements having remained about the same. Occupation with these materials had evidently been increased by their availability at home. As is becoming apparent after decades of much wide-eyed enthusiasm about these new instruction technologies, their effectiveness is not yet guaranteed by mere application and acceptance, not even by the very quality of programs, but is dependent in a complex way on their being embedded into the subject matter, curriculum, personal teaching, availability, and, last but not least, pressure from examinations covering these materials resulting from the minimalist attitude of many students toward learning, i.e., “learning only what is needed to pass.”

Staff requirements. In contrast to popular expectations—and also, unfortunately, those of funding institutions—this close integration of computers into classes required additional staff rather than saving staff. Demanding programs, such as those for data analyses in practicals or simulations in seminars, necessitated assistance from tutors; this was generally the case when programs were in English. In addition, the operation of a big system such as MILES, comprising large stocks of constantly changing materials, turned out to require at least two full-time positions, one for programming and one for data input and assemblage of teaching units. Because grants are not available for the routine operation of such systems, these positions had to be provided by the department through the sacrifice of part of the already small academic staff, which comprises altogether only seven positions. Thus the application of this media can be advocated not on the basis of reduction of costs but only on the basis of an improvement of the quality of education.

Production problems. The most severe handicap for the project proved to be the general lack of materials, especially those meeting high academic standards—not only materials for proper programs, such as tools or simulations, but also those for the

components, such as bases of picture and film collections suitable for building up individual teaching units. On the other hand, the abilities of individual staff members to produce good teaching material turned out to be very limited because of the necessary high expenditure of physiological and technical expertise. Thus the simple incorporation of a figure from scientific literature in MILES may require only minutes for scanning but hours for commenting and allocating key words in the respective database document. Correspondingly, working out a fairly intelligent simulation can take months of time. As a consequence, most of our high-flown initial intentions to produce sophisticated interactive programs had to be abandoned in the course of the project. Typically, none of the few multimedia projects conceived 10 years ago in Essen along with MILES in the sense of the new microcomputer era (and presented rashly in a public relations publication by the university; see Ref. 15) came into existence or survived beyond the experimental stage. The supply of materials is only developing slowly. For productions of German origin, only practicals are fairly covered by data acquisition and analysis programs available from various departments. Most publishers are presently just sounding out the market, for instance, by (ineptly) offering the figures in their textbooks concomitantly on CD (13). Sophisticated simulations are mostly of Anglo-American origin, but, because of the language barrier, these are only of limited use for our students. At present, the celebrated Internet carries essentially only information about products but not these products themselves; the "data superhighways" are largely empty with regard to teaching materials for physiology, at least for commercial products. Especially detrimental is the present copyright situation, preventing not only the uncomplicated handing out to students but also the exchange between institutes of material collected individually from commercially available sources. Because of the lack of a general regulation for the acquisition and transfer of educational material on electronic media, individual, hence, practically infeasible, negotiations are necessary with each publisher or producer. As a consequence, systems such as MILES/SMP are, at present, not transferable, because all users would have to build up the database anew, and they will not.

Acceptance by academic staff. The present situation also severely impedes the consideration of the

new media by staff. To understand this fully, one must know that in German universities the emphasis lies traditionally more on research than on teaching, although the latter is also obligatory for academic staff. Because the establishment of this media is very laborious and time consuming, it requires the sacrifice of other activities such as research, a consequence most physiologists, despite the common lip service given to these technologies, feel they cannot afford. As an example, consider the consequences for myself when, after the grants for developing MILES/SMP had run out in 1987 and the limited support by the regular academic staff as well as the indifference of the medical school became apparent, I had to give up my experimental research to keep this project alive. Typically, prominent scientists do not yet participate in the production of media; at best they write textbooks. The situation is especially crucial for the junior staff, because an academic career depends more on the merits of research than on those of teaching; spending too much time on the development of media may turn out to be detrimental to professional advancement. This attitude also manifests itself in the meetings of the Deutsche Physiologische Gesellschaft; programs up to 1992 did not even contain a regular section on "teaching;" only in 1997 did the society decide to set up a continual panel for this topic. Consequently, there exists a distinct discrepancy, typical for the current situation in medicine in Germany, between impressive reports on progress at national as well as international conferences and deficiencies on the actual teaching level.

PERSPECTIVES

Virtual university. Concepts for adequate application of multimedia are extremely controversial, ranging from entire computer-mediated curricula to merely focal integration into traditional teaching and learning. The development of worldwide broadband communication nets has given rise to euphoric visions of future "virtual universities" replacing the traditional ones with nationwide, or even global, computer-based distant education (3). These scenarios are surely exaggerated. The idea of one uniform set of teaching programs in physiology and, correspondingly, in all of medicine, developed in these institutions and distributed nationwide via the Internet to be downloaded

anywhere by students for home study, is beyond reality, as were the conceptional forerunners advocating production of "the optimal textbook" or video recordings of "the optimal lectures" as the common basis for education. Similarly, visions of general distant on-line seminars and oral examinations via video conferencing appear illusory. In addition, the idea of future students using the new freedom of global access to teaching materials to compose their own curricula by "surfing" the Internet is bizarre.

Multimedia curriculum. Nevertheless, irrespective of such scenarios, it has factually become possible to impart, on-line or off-line, for supraregional as well as local applications, all nonpractical subject matter in physiology via media. However, extensive concepts of this kind appear problematic for several reasons. 1) By incorporating knowledge conveyed until now by textbooks, teaching programs would necessarily contain huge amounts of text. This is already becoming apparent in MILES, in which lecture notes tend to become longer every year. Because computers, as mediators of continuous text, are still clearly inferior to books, at present it does not make sense to replace these generally with computers; this will change in the future, when "book-equivalent" notebooks become available. 2) The argument, attractive at first glance, that transfer of the entire subject matter via computer would create the ability to provide overall interactive learning turns out to be questionable. Much of this matter, if current intellectual standards for the admission of our students are to be maintained, does not require transformation into endless, hence, inevitably tedious, tutorials. Even just covering all important topics by using highly interactive programs of the simulation type would not be feasible on account of both the expenditure required for their production and the strain of students having to plow through such enormous assignments. 3) Personal contacts between students and teachers are a fundamental need for both groups and appear indispensable for development not only of certain intellectual abilities of students (and staff) but also of important social behavioral patterns acquired during study at the university.

Future development. Certainly the new media will, in the long run, change education in physiology and

medicine by increasing the share of computer-based materials with a wide rather than uniform scope of topics, forms, and standards, distributed in competition nationally and even internationally and studied at home. Without a doubt, this will also change the role of personal teaching. The latter will, as our experiences with MILES indicate, certainly become easier in some respects but more demanding in others. The emphasis can be expected to shift toward less fact- and more problem-oriented teaching. These media will also provide new methods of communication between staff and students and will take over organizational functions such as information, admission, and written exams (10). The training for diagnostic procedures and skills such as the examination of patients, operations, and even laboratory procedures, will become more effective by calling on interactive multimedia programs. Nevertheless, direct experience under the guidance of teachers will remain indispensable. Thus, in accordance with conclusions from related projects (4), we are convinced that integration of the new media into personal teaching as well as, at least provisionally, books will emerge as the optimal application concept. For efficiency of this cast, it will be essential to consider the specific suitabilities of the new media for particular tasks. Domains for their application may be expected to be 1) databases, providing general availability of pictures, films, and signal recordings and furnishing components for the local composition of teachware; 2) simulations of biologic functions, of skills and practices, and of diagnostic procedures, using increasingly interactive video and CAD techniques; 3) tools for the acquisition and processing of data of all kinds; 4) test materials for the evaluation of knowledge and skills, also utilizing multimedia techniques; 5) "open" authoring systems for the local composition or adaptation of demonstration and teaching units; and 6) tutorials, for which (for reasons stated above) we see no exhaustive need.

Still some way to go. Despite the external support undoubtedly necessary to introduce the new media into teaching and learning, the most effective motor will prove to be the common professional use of computers, making this an express demand as an additional tool for education. This appears to be the

main reason for the striking difference between fields such as informatics, surveying, and engineering, which are already largely computerized in teaching, and those of art history and medicine, which are underdeveloped in this respect. In the latter field, computers have not yet become specific tools for the general practitioner, to whom the medical curriculum in our country is entirely oriented. There are also national differences. The application of these technologies is, at present, evidently more advanced in the United States and in Great Britain than in Germany (5). Here, after all, the conference of university presidents has recently issued recommendations for promoting the new media (8), and state governments (all medical schools in Germany but one are state owned) are also requesting medical schools to work out respective development plans. However, this will take time, because realization will require structural changes of institutions, curricula, funding policies, and mentality. Therefore, it may well be another decade before these media—already proclaimed overall victorious—will really have conquered education in medicine.

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