

Quality Criteria for Electronic Publications in Medicine

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Abstract: This paper defines „electronic publications in medicine (EPM)“ as computer based training programs, databases, knowledge-based systems, multimedia applications and electronic books running on standard platforms and available by usual distribution channels. A detailed catalogue of quality criteria as a basis for development and evaluation of EPMs is presented. The necessity to raise the quality level of electronic publications is stressed considering aspects of domain knowledge, software engineering, media development, interface design and didactics.

1 Introduction

Due to CD-ROM technology and the Internet a rapidly increasing number of medical electronic publications is available for the public. The former division in computer based training programs, databases, knowledge based systems and electronic books has vanished with the advent of the hypertext and multimedia paradigm. This justifies to define „Electronic Publications in Medicine“ (EPMs) as a new kind of media, that certainly will attain outstanding importance in future.

As a result of our experience of developing and evaluating EPMs, as well as implementing a large EPM on-line library in a German university hospital we observe an alarming lack of quality in many of these products, that compels us to elaborate a catalogue of quality criteria. The criteria are proposed to serve as a basis for evaluation of existing software and as guidelines for software development. In general, subsets of these criteria can be sensibly applied to a given product according to its specification.

2 Definition

As a consequence of the standardisation of platforms, storage media, communication protocols and distribution channels we define Electronic Publications in Medicine (EPMs) as follows:

- The subject of EPMs is health related theoretical and practical knowledge.
- Target users are professionals and students in the Health sector, but also medical laymen (such as interested patients).
- Goals of EPMs are the acquisition, consolidation, repetition and update of health-related skills, knowledge and information as well as decision support.
- The use of EPMs does not require special computer skills.
- EPMs are single-user oriented, a linkage with an existing Health communication infra-structure is no prerequisite (even though useful in certain applications
- such as expert systems or coding systems).
- EPM are author products: Defined authors (persons or institutions) are responsible for the medical contents.
- The term „Electronic Publications in Medicine“ implies public accessibility. This includes commercial and public domain products. A WWW based tutorial,
- WWW based medical journals and shareware CBT programs available via FTP are electronic publications as well as CD-ROMs available in a bookstore.

We differentiate EPMs from other software used in Health institutions such as software tools (text processors, presentation software, expert shells) that do not transmit specific contents, components of hospital information systems for patient-related data management, statistic packages for analysis of medical or administrative data, electronic media that meet the criteria above cited but that have no health-related content.

Furthermore we exclude – in order to assure homogeneity and comparability –

- electronic and semi-electronic publications that use analogous techniques (video publications, slide shows, audio-tape based media), because they will be
- gradually replaced by digital techniques,
- learning environments based on proprietary platforms or necessitating special input and output devices, since availability cannot be taken for granted,
- environments for distributed, co-operative learning as they require a logistic not covered by the product itself.

3 Classification of Electronic Publications in Medicine

For describing EPMs we suggest the following system of (nearly) orthogonal axes of features:

3.1 Data / knowledge

- sequential / non-sequential presentation of informational units
- structure of informational units (database, SGML etc.)
- knowledge representation using AI methods and inference algorithms

3.2 Media

- written text
- graphics
- digitised photographs or pictures
- digitised audio documents, spoken text
- animation
- video documents

3.3 Dialogue, didactics

- degree of interaction (proportion of active and passive sequences)
- type of interaction (browsing, retrieval, simulation, querying, feedback)
- type of didactic dialogue (simple, intelligent, open, closed)
- didactic scenarios (self learning, exercise guided by a tutor, combination with other didactic resources, integration in curricula)

3.4 Software / document formats

- programming languages
- mark-up languages
- authoring tools

3.5 Platform

- hardware
- operating systems
- communication protocols
- browsers, plug-ins

3.6 Target users

- laymen, patients
- students (medicine, nursing, ...)
- physicians, nurses
- other health related personnel

- undefined

3.7 Contents

- clinical medicine (surgery, cardiology, ...)
- theoretical medicine (anatomy, physiology, ...)
- Public Health
- other Health related disciplines (nursing, physiotherapy, ...)
- coding systems, nomenclatures, thesauri, ...
- medical literature

4 Criteria catalogue

The development of good EPM requires the following expertise:

- domain competence
- competence in software engineering
- design competence

and in the case of multimedia or educational systems additionally

- media competence
- didactic competence

In the following a comprehensive catalogue is presented. It is divided in the subheadings contents, software engineering, media, ergonomics and interface design, dialogue and didactics. Which criterion applies to a specific type of application is not specified separately since it is expected to result from the context it is being used in.

4.1 Contents

Quality criteria that apply to the contents of EPMS are mainly the same as for conventional publications.

- The contents are based upon the state of the art in biomedical science and clinical practice. They are presented correctly, comprehensively and adapted to the target group specified. Personal opinions are explicitly marked.
- Authors, editors, release date and version are documented.
- Commercial publications are reviewed.
- Commercial publications are listed in book catalogues.
- Copyright information exists.
- License agreements contain explicit statements on multi-user operation, loan and rental.
- Target users, prerequisite skills and learning objectives are adequately specified.
- Scope and granularity of the contents are perceptible.
- Where standardised curricula exist, they are referenced in educational software.
- The medical contents are linked to existing coding schemes and controlled vocabularies.
- A bibliography exists.
- The contents are kept current by periodical updates.
- In the case of contents that get rapidly obsolete, an expiration date is given.
- Knowledge based systems are periodically updated by domain experts.

- Systems for clinical decision-support are clinically evaluated.

4.2 *Software engineering*

- The system requirements are clearly identified.
- The application is stable, robust against improper use, reliable and of good performance.
- Basic functions of the application can (optionally) be started directly from the data medium without setup routine.
- The application runs without modifying system areas of the operating system.
- There is no need of system reboot or manual modification of the configuration to start the application the first time.
- Where an installation routine cannot be avoided, all system modifications are clearly documented and an uninstall routine is available.
- The application is developed for the most common platform among target users. Ideally more than one platform is supported and the same functionality is available on any platform.
- Special display properties (fixed display resolution or colour settings) are only acceptable if the graphical contents of the software makes it unavoidable.
- The software can be installed on a file server without the need of separate client installations.
- The software (this applies mainly for databases) runs as a real client / server application with clients for different platforms.
- Installation on a multi-user operating system is supported.
- Multi-user operation supports storing of user-specific settings.
- The application does not affront the users' patience by long loading times.
- Where there are considerable response delays, a warning is displayed.
- No special computer skills are necessary.
- Interfaces for linking with complex systems (hospital information systems, text retrieval systems) are defined and documentation is available.

The following refers to Internet based publications:

- There is a sensible compromise between ease of operation, friendly design and runtime performance. Realistic data transfer rates are taken into account.
- Large pictures can be previewed („thumbnails“).
- Security issues are taken serious where plug-ins are requested. Plug-ins are not used where there exists a good alternative.
- Internet-based publications that do not communicate with processes running on the server have the option of an en-bloc download of the entire package for local use.
- Sensible combinations of on-line and off-line elements aiming at a reduction of communication costs are supported..

4.3 *Media*

4.3.1 *Text / Hypertext*

Generally, text is much better readable on paper than on a screen. Therefore the electronic presentation of large amounts of text without additional functionality must be justified by availability, up-to-date information and costs.

- The contents are expressed tersely and compactly.
- Texts are orthographically, grammatically and stylistically correct.

- Where the application focuses on the presentation of large amounts of sequential texts, manageable, numerated hardcopies can be generated.
- Tutorial systems do not appear with screen full of texts. Scrolling is avoided as far as possible in these systems and the rule „one topic - one window“ is applied whenever possible.
- Headlines and short, compact phrases may contrast with an individual typography, whereas normal text is displayed using standard fonts.
- Where the training or retrieval of foreign terms is given special emphasis, an acoustical support of the pronunciation is available, or at least a transcription into the international phonetic alphabet (IPA) is given.
- Seldom used terms are explained by a glossary or a lexicon.
- A hypertext based publication has powerful orientation tools that can be used intuitively.
- The „hyperspace“ of the publication can be graphically visualised (site maps, dynamic diagrams).
- The total volume of the publication is transparent .
- For each chapter the number of pages is indicated.
- A hierarchical order of pages is supported by a logical numbering. Even if the arrangement of pages follows more than one ordering principle, one preferential order is identified.
- If in a hypertext document a sequential order makes sense, this order can be followed by a special type of hyperlink without any page being skipped.
- Index pages that consist mainly of links and text pages with few links are easily distinguishable.
- An excess of hyperlinks in non-index pages is avoided. Links of different types are discriminated by layout.
- Links pointing to pages outside the given Internet publication have a different layout to prevent unperceived leaving of the publication.
- Where „gateways“ to other Internet publications are intended the user is informed how to return to the original document.
- The layout of „visited links“ contrasts with that of other, not yet visited links.
- A history list and „back“ and „forward“ buttons are supplied. In examination sequences within tutorial systems the history list can be disabled.
- Bookmarks can be modified by the user and notepad entries can be linked to any page.
- Large texts can be searched by means of powerful text retrieval tools, such as index based and free text retrieval, but also probabilistic and thesaurus based search. Boolean operators and regular expressions are supported. The scope of the retrieval is the complete publication.
- The usage of retrieval tools is explained in an on-line help using concrete examples.
- In languages where orthographic variations in medical texts are common (i. e. German), spelling tolerant retrieval techniques are used.
- Internet based publications that change frequently show the date of the last update and a version number. Substantial changes of contents are documented.
- The consistency of external links is frequently checked by the publisher.

4.3.2 Graphics, pictures, animation, video and audio sequences

Special requirements for technical realisation and quality are not addressed here as they are not specific for EPMs. Technical guidelines for media production and design must be consulted.

- Photographic and graphic techniques, colours, illumination, digitalisation, speech recording etc. meet professional criteria.
- Resolution and colour depth of pictures are determined by the contents on one hand and by the hardware commonly available among the target users.
- Graphic resources higher than the one required are always supported.

- If used with insufficient graphical resources a warning is displayed.
- A colour depth of 8 bit is normally sufficient for medical photographs or painted pictures. An optimisation of the palette is only acceptable if the loss of colour quality is neglectable.
- Zooming pictures offer more visual information than a simple magnification of the single pixels.
- Pictures, graphics and tables are numbered and labelled.
- Animated sequences and video clips are mainly employed to carry information.
- Animated sequences and video clips can be used to produce decorative or dramaturgical effects in the context of a well planned, consequent design of the user interface. They do not produce undesirable delay or interruption.
- Animated sequences and video clips are mainly used where they transport information better than still pictures.
- Movie-like pre title and end title sequences can be skipped or switched off.
- Video sequences are only employed where high performance graphics can be expected and a bad resolution or a jerky display do not occur.
- Where medical acoustic phenomena occur in a didactic context they are available as audio clips.
- Extensive dialogues (doctor – patient etc.) are not only displayed as written text but also available as audio documents.
- Sound tracks may be useful if they motivate without causing distraction or if they raise the concentration as dramaturgical effects.
- Sound tracks can be switched off.

4.3.3 Interaction of media and co-operation of media

- Contents, target groups and didactic concepts determine which media are used.
- Users are informed at the beginning of the application which media they will encounter.
- The division in active (browsing, simulation, didactic dialogue) and passive (sound, video, slide show like presentations, reading of plain text) communication elements is transparent.
- Passive sequences require attention over a certain period, that is quantified before starting.
- Passive sequences are launched actively by the user and can be interrupted and aborted at any time.
- A frequent switching between active and passive sequences occurs only within a script that is plausible for the user.
- Spoken texts can optionally be displayed. Texts already listened to are marked on the display.
- In didactic systems multimedia presentation of contents is preferable to textual presentation.

4.4 *Ergonomy and graphical user interface design*

Numerous guidelines for graphical user interface (GUI) design give detailed, but occasionally contradictory advice (see literature). In the following section the authors stress some of those guidelines considered especially important for electronic publications in medicine.

- The application's GUI originates individuality, motivates the user by visual stimuli and facilitates interaction with the software.
- The GUI is guided by standards familiar to the user.
- Especially the following features should be modelled after well-known standard applications (Office software, WWW browsers, Mail programs, functions of the operating system):
 - navigation tools in hypertexts
 - controls for playing audio and video sequences (tape-deck metaphor)
 - saving of user-specific options
 - file operations

- retrieval functions
- functionality of mouse buttons.
- Number and variety of controls (buttons etc.) is limited to the necessary.
- Controls on the main window always have the same position and continue to stay visible when disabled. They are clearly identifiable.
- The functions of the control elements are explained in an on-line help module.
- It is always evident which areas on the screen are sensible to mouse click and which are not.
- Mouse functions can alternatively invoked by key shortcuts.
- The application can be ended at any time and at any place.
- Functions that are expected to be used less frequently, are invoked by additional windows or through the menu bar, but not directly by buttons on the main window. Standardised windows contain always the same kind of information.
- The number of simultaneously open windows is limited.
- The more user interaction needed, the more necessary is the use of common GUI standards.
- If the GUI is has an uncommon and experimental design, the same creative philosophy applies consequently to the whole of the application.
- The colours of backgrounds, forms and controls are discrete and unobtrusive. Colours do not complicate the legibility of text and the usability of graphical elements.
- Colour is never used as the only carrier of information (colour-blindness!)
- The symbolism of colours and fonts is consistent and modelled after standard applications.
- Icons use metaphors that are plausible for the target users. Icons familiar from standard software are used if possible.
- The function of control buttons is always evident.
- Texts and graphics can be printed at any time.
- The choice of stylistic and decorative elements depends on the target users and motivates them to use the application.
- The basic functions of the application can be handled without consultation of manuals or the help function.
- The availability of a printed manual is not necessarily a quality criterion. If it exists it is complete, correct and user-friendly.
- All manual entries can be alternatively invoked out of the application and can be printed.
- Help functions are context sensitive, printable and searchable. The hypertext criteria (above) apply also to help functions.

4.5 *Dialogue and Didactics*

CBT programs should raise the learners' motivation and make them to have fun provided that this complies with the requirements of the curriculum. As they generally concur with traditional forms of learning and teaching, they must provide a comparable didactic efficacy, as far as this can be evaluated. The added value of CBT consists in bridging gaps between conventional forms of teaching and learning.

Many CBT programs are designed for autodidact learning: Students select the software according to their individual preferences and learning styles. Teachers should give recommendations concerning software they consider appropriate and relevant to the curriculum. Where educational programs are embedded into the curriculum, a concept for implementation has to be formulated, and experiences made by others have to be taken into account.

- The contents, workload and learning objectives are specified.
- The didactic material has a modular structure.

- In those EPMs that are not to be considered to be pure training programs, the didactic components are clearly distinguished from other components. The size of contents and the average time needed are specified.
- Didactic dialogues consist not only of closed questions (multiple choice, attribution, marking of objects) but also of open questions (free text, gap text, syllable quiz, fault correction).
- Didactic situations (lectures, practical exercises, exams etc.) are simulated.
- The processing of free text supports orthographic variations, word morphology and synonyms.
- Free text input can be corrected.
- Simulations create a realistic scenario, if necessary with graphical elements, animated sequences and pictures.
- Visualisations and realistic settings are used to evoke associations with the user's experiences.
- Passive sequences refer to an explicit problem that can be worked up by the user after the sequence.
- Test situations are characterised by
 - positive reinforcement
 - variation
 - sensible choice of distractors at MC-questions
 - among 4 to 8 choices at MC-questions
 - progressive hints
 - corrective feedback and consolidation of the topic
 - „intelligent“ presentation of the topic according to learner performance
 - random presentation of questions as a user's option
 - skipping of questions
 - optional recall of the correct answer
- A textual or graphical feedback of progress is available.
- Within a didactic sequence orientation is always possible.
- Sequences already finished are marked.
- Training sessions can be interrupted, resumed and aborted by the user at any time.
- The degree of learner control within the training session depends on the user. For beginners a „guided tour“ with little interaction is available.
- A high degree of learner control within the training session requires that there is no rigid logical sequence between the elements.
- It is possible to limit learner control at the beginning and raise the user's independence progressively.
- Game and competition like elements (high-score-tables etc.) raise motivation and reduce monotony.
- Dramaturgical elements: embedding in a frame story, simulation, role-playing, suspense, humour, anecdotes, cartoons, rhetoric questions - are used with the same effect. The choice of these elements is oriented by the communication code of the target group.
- At the end of the training session an appropriate assessment is given.

5 Discussion

Unfortunately the quality of many EPMs is still not satisfactory. There are only a few projects that excel in all domain, software, media, interface design and didactic know-how as described in the above catalogue of criteria.

It must be acknowledged that due to the vast differences in the goals of existing EPMs certainly not all of these criteria might apply to a specific publication. Some might be even contraproductive.

The proposed catalogue might help to identify the most important criteria for a specific type either for the development or the evaluation of the EPM. An on-line version of this document is open to discussion at http://www.imbi.uni-freiburg.de/medinf/kat_e.htm.

6 Literature

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