www.tnt-radiology.de: Teach and be Taught Radiology: Implementation of A Web-Based Training Program Based on User Preferences as Determined by Survery[1]

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Over the last 10 years, a number of excellent resources for radiology education and training, both for undergraduate and graduate users, has been published on the Internet (1–13).

Nevertheless, after the gold rush mentality of the late 1990s and excessive euphoria of 2000, general disillusionment with regard to Web-based radiology education has taken hold (14). We regard this as an opportunity to look at possible reasons why Web-based education in the field of radiology is languishing and to suggest possible remedies.

Ignorance, suspiciousness, and downright mistrust of digital media are still prevalent among students and university teachers, partly because of plain inertia. Sadly, an assessment made by Friedman in 1996 (15) is still largely relevant today: acceptance of computer-assisted instruction programs is hampered by poor instructional design

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and lack of integration into medical school curricula and testing routines.

Although the Internet has been accepted as a global information platform, and Web-based offerings such as Google, eBay, and PubMed are shaping today's reality for many, the potential of teaching on the Internet has not been fully realized, and existing teaching resources have not achieved similar levels of acceptance.

The objective of this work was to identify the needs and expectations of both teachers and learners of diagnostic radiology and to design a tailored teaching program that meets those needs to the largest possible extent. Drawing on the knowledge gained from a survey, we created a user-centered, self-explanatory site that provides high-quality information along with features and interactive functions matched to the wishes expressed by respondents, under a liberal copyright policy that allows copying for personal and academic purposes.

MATERIALS AND METHODS

Target Audience

To address a wide audience, we defined our target group as including every person who teaches radiology, works with radiologic images professionally, or, according to their own perception, would benefit from increased knowledge of their interpretation.

Interview

In a pilot study, we distributed a request to participate along with a questionnaire via e-mail. The questions were designed to elicit user preferences with respect to design, interactivity, and layout of various radiology Web sites. The response to the pilot survey was unsatisfactory in that respondents understood these and other terms used in the questions in different ways, many of them diverging strongly from the intended meaning. We therefore decided to conduct the survey using personal interviews.

A group of 483 members of the target audience (381 undergraduate medical students, 52 radiologists and physicians of other specialties, 28 university lecturers in radiology, 22 radiographers) was asked to participate. Sampling was by convenience. Students were from the University of Erlangen-Nuremberg Medical School, radiographers were from the Institute of Diagnostic Radiology, and physicians/radiologists were from Erlangen-Nuremberg and several other German universities.

All interviewers (MG, DA, DK, MW) participated in the development of the interview guide. Interviews took place at the console of a personal computer connected to the Internet, so that preferences could be elicited using examples. Example pages for illustrating and clarifying interview questions were taken from Auntminnie.com (http://www.auntminnie.com), mypacs.net (1), CONRAD (2), COMPARE (7), Medpix (http://rad.usuhs.mil/medpix/medpix.html?mode=default), ELERA (16), and Eurorad (3).

We requested interviewees opinions and comments in the following categories.

Layout

We recorded interviewees likes and dislikes, as well as reasons for these preferences, with regard to arrangement of information on the Web pages.

Interactivity

Different models of interaction between the user and the presentation, as provided by the previously mentioned sites, were demonstrated. Comments and expressions of preference were recorded.

Download Times

We elicited how much of a delay between the page request ("clicking" on a link) and the completion of the page display was tolerable.

Contents

We asked participants to voice expectations and comments regarding the type, breadth, depth, and structure of information provided.

Copyright License

Features of various content licenses (allowing copying for personal use [COMPARE], disallowing copying [Medpix, mypacs.net, Auntminnie]) were listed, and users were asked to comment on how they felt these restrictions would affect them.

Acceptance of Costs

Participants were asked whether and how much they would be willing to pay for using an Internet resource that met their personal requirements.

Login and Registration Requirements

Interviewees' opinions on registration procedures and privacy concerns were elicited and recorded.

Pointers to External Resources

We asked participants about links and references to other Internet-based materials: whether they need or desire such pointers and whether they find it difficult or acceptable having to adapt to different presentation styles after following them.

Cooperation

We asked whether participants thought it was important for users to be able to make contributions to the content and design of teaching Web sites.

Maintenance

We elicited expectations regarding ongoing maintenance of Web offerings.

Perception of Media Technology

We asked participants to describe their attitude towards Internet education, looking for indications of anxiety and mistrust toward the technology and its individual and societal impact.

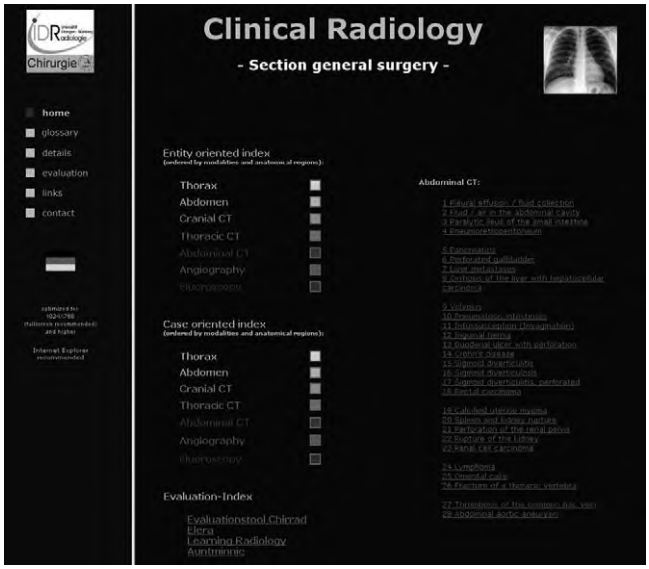

Figure 1. The entry page is accessible from all pages via the Home link in the navigation bar on the left and provides links to all indices within the program. The navigation bar additionally offers basic usage hints and links to a comment/feedback page and to a list of related external sites. All pages were designed for best viewing at a screen resolution of 1024 × 768 pixels.

TNT-RADIOLOGY: PREPARATION OF THE PROGRAM

Rationale

We used the results of the survey to create a radiology teaching Web site that addresses the requirements of the widest possible audience.

Case Preparation

Radiologic images (radiographs and angiographic, fluoroscopic, magnetic resonance, and computed tomography images) were obtained from the archive of the Institute of Diagnostic Radiology of the University of Erlangen-Nuremberg over a period of 1 year. As part of the departmental reporting routine, interesting and educationally valuable cases were identified by training radiologists in cooperation with a senior radiologist (HG), who determined which individual images (angiography, fluoroscopy), sequences (magnetic resonance), and window/level settings (computed tomography) were most representative of the teaching point for which the case was selected. Images were independently reviewed for image quality. A total of 500 example cases were selected in this way.

Generally, images were available in Digital Imaging and Communications in Medicine (DICOM) format. Using dual-monitor picture archiving and communication systems workstations, relevant images were placed together on the screens and saved as a screen shot in the JPEG (Joint Photographic Experts Group) file interchange format for inclusion in the program. In 20% of the cases included in the program, images were only available as hardcopies. These were scanned in a film digitizer (Lumiscan 75, Lumisys Inc, Sunnyvale, CA).

At the editing stage, regions of interest were cropped from the images to reduce the amount of data that needed to be transferred when using the program (17). After this step, images were again reviewed by HG. Images were then anonymized, converted to gray levels, and scaled to fit pages that were designed for viewing at a screen resolution of 1024 × 768 pixels (Fig 1). Where necessary, brightness, contrast, and sharpness were corrected. For all image processing tasks, we used PhotoImpact Software (Version 4.0, Ulead Systems Inc, Torrance, CA). Overlays showing graphical annotations and outlines highlighting structures of interest were produced using CorelDraw software (Version 7.373, Corel Corp, Ottawa, Ontario, Canada).

Assembling the teaching case was a task performed by students as part of their voluntary engagement in the Institute's "Medical Edutainment" special interest group. Images selected for inclusion in the teaching case were compiled into Microsoft PowerPoint (Microsoft Corp,

Redmond, WA) files (one per case) and printed on paper. These hard copies were handed back to a team consisting of the radiologist and clinicians involved with the case, who added case information in writing (patient history, clinical findings, diagnosis, differential diagnoses, and relevant Web links). Using a colored marker, the radiologist highlighted text sections that referred to regions of interest in the images and outlines these regions using the same color. This ensures that descriptions and image annotations/outlines referred to one another unambiguously. We refer to the result of this work on the hardcopy as the *case script.*

Finished case scripts were returned to the students, who used a personal computer workstation to build Web pages from the source images and the information contained in the case script. Each case was then reviewed online by a radiologist. On approval, the case was then released to the public.

Programming

MG and DK composed the pages' basic design using a web authoring system (Dreamweaver Version 3.0, Macromedia, San Francisco, CA). The software supports the creation of Web page code that is rendered in the same way by different graphical Web clients on different computing platforms ("cross-browser scripting"). We made use of the software's advanced design and layout tools to create dynamic behaviors, such as displaying or hiding page layers depending on user input (18).

RESULTS

Interviewee Preferences

Interviewees of all ages and experience in radiology preferred a simple layout with either a single content page or a content page plus a navigation frame. A navigation feature considered important by most users was a "back" button that leads to a familiar starting page. Long pages that require scrolling were unpopular—users preferred pages that show their full content on a single screen, with options to retrieve additional information either on separate pages, in pop-up windows or as dynamic layers that are hidden at first, revealing annotations on user request. Generally, users appreciated Web sites that followed a slide-show model of content presentation, with each page communicating a single teaching point "at a glance." Most participants worked with a display resolution of at least 800 × 600 pixels on their own computers. Those who used higher resolutions (predominantly lecturers in our sample) appreciated a zoom function on the images.

Interactive features were of critical importance. Undergraduate students in particular favored optional graphical annotations and additional information on image overlays. Most interviewees appreciated that looking at a plain image first and then retrieving additional information can benefit learning, because the initial impression can be assessed and corrected based on the interactively provided annotations. Students welcomed such overlays for self assessment, whereas lecturers saw their value for teaching sessions. Even participants with plenty of radiologic knowledge appreciated interactive graphic features for quick perusal of images and findings in a page.

Although some of the participants were users of broadband Internet connections, a larger number still accessed the Internet through modem connections over analog telephone lines with a maximum throughput of 56 kilobits per second. Page load times on some radiology sites (Auntminnie.com, mypacs.net, Medpix) were deemed unacceptable for the majority of these users. Other sites were seen as more suitable for narrowband use (COMPARE, ELERA).

With regard to contents, participants expressed a strong preference for comprehensiveness and uniform quality in teaching Web sites. Sites that provide inconsistent quality were rated as unpopular, even if some of their case presentations were worked up very thoroughly. Links to related information on external sites were fully acceptable and even preferred by a majority of users. Students expressed their desire for lecturers to draw on Internet-accessible materials, which could be reviewed online before or after formal teaching sessions. On the other hand, lecturers saw benefits in using online cases for teaching that students could access as well. Many of them were already using or expressed their intention to try using internet materials via links from electronic presentation files of their own.

Users have varying preferences for indexing hierarchies and styles. The same is true for features enabling the assessment of learning progress, either of oneself (important for students) or others (important for lecturers). This probably reflects a large variety of learning and teaching styles across our sample.

Teachers and clinicians valued the possibility of using copied web site materials on an offline portable computer during bedside teaching and in other situations where an internet connection is unavailable. Legitimate copying is also appreciated by student users,

especially as a remedy for the perceived lack of reliability of Web sites with respect to their future accessibility.

Participants were generally unwilling to pay for the use of programs offered via the Internet. Among the students interviewed, for example, the majority are willing to spend 10% of their book budget or less on licenses for online materials.

All users more or less vehemently expressed a dislike of registration requirements and login routines.

Most of the interviewees agreed that involvement of the target groups in the creation of teaching material was beneficial. It was noted that digital media offer a range of dynamic features, compared with traditional media, and that, to use this potential sensibly, users should be involved in design decisions as well.

Many participants described previous disappointing experiences with poorly maintained sites that provide broken links. As a result of those experiences, they demand that Web authors keep their sites current. If a page is moved within a site, users expect automatic redirection to reduce the frustration caused by dead-end links.

A skeptical attitude toward digital media was prevalent in all subgroups of the studied population. Many participants had doubts about the reliability of access to information presented online. This concern is also reflected in the desire, as noted above, to be able to make legitimate local copies of Web site contents.

Among users with higher levels of radiologic knowledge and qualification, skepticism toward Web site contents was pronounced. Here, the main concern was about the accuracy and veracity of the content. Confidence in printed books and journals was higher in comparison. A common perception was that peer review of Web site contents was below the standard of printed materials.

"TNT-RADIOLOGY" WEB PROGRAM

Structure and Layout

Considering the majority preference, we chose a page layout that was optimized for screen resolution of 1024 × 768 pixels. To suit the needs of users equipped with higher resolution displays, we included an option to scale images up. Text and annotations were presented on optional layers. Scroll bars could be avoided with this approach. A single set of navigation buttons was included in the page design.

Figure 2. For the presentation of each case module, we adhered to a strict pattern of radiologic image, clinical history, findings, diagnosis, and external links with differential diagnoses.

Case Modules

For the presentation of each case module, we adhered to a strict pattern of radiologic image, clinical history, findings, diagnosis, and external links with differential diagnoses (Fig 2). Generally, the description and findings are loaded, but not shown when the page is first retrieved (Fig 3). This enables didactic use of the pages: the user has full control over the sequence in which additional information is presented. Only when accessing the pages via the entity index is the page information shown all at once (Fig 2).

We provide detailed descriptions of findings in the image shown. When hovering the mouse pointer over underlined text sections, the relevant structures in the image are highlighted in color (Fig 4). Information on diagnoses and differential diagnoses is provided in a more terse style; for further details, users can follow external Internet links. We thus avoid duplicating general textbook information within the case modules.

The text color of the descriptions of pathologic findings was also used for annotations in the images, enabling to correlate text with image features at a glance.

The cases shown represent what, in our view, are the 500 most clinically and radiologically relevant diagnoses for teaching students.

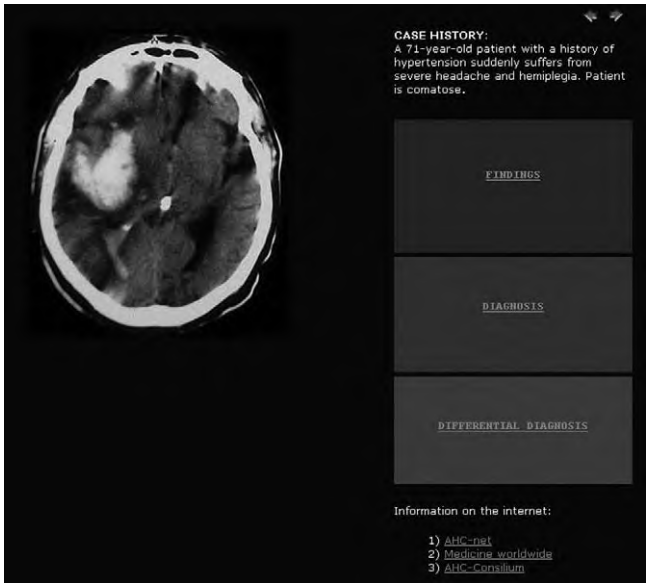

Figure 3. Generally, the description and findings are loaded, but not shown when the page is first retrieved. This enables didactic use of the pages: the user has full control over the sequence in which additional information is presented.

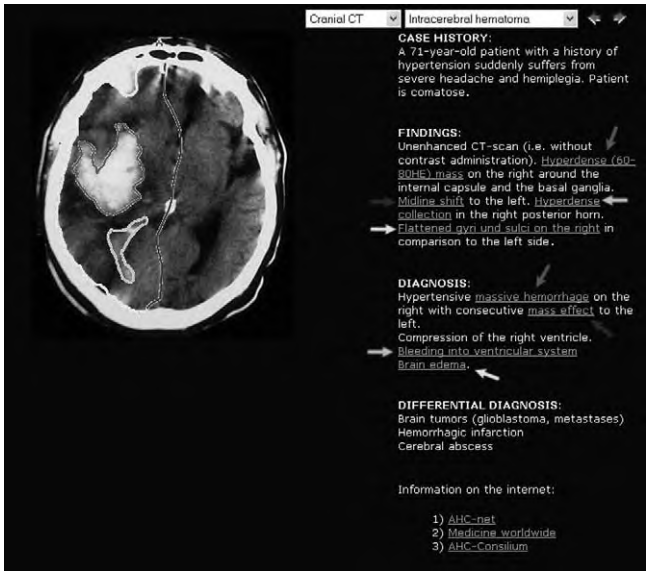

Figure 4. We provide detailed descriptions of findings in the image shown. When hovering the mouse pointer over underlined text sections, the relevant structures in the image are highlighted in color.

Indices

The case modules are accessible via three different index hierarchies. This enables users to approach the material in a way that suits the learning situation.

When retrieving a module using the *case-based index*, users see the relevant information in the same sequence as they would in a clinical reporting situation. Images are shown with basic reference details: history, findings from the physical examination, and laboratory tests). This index is designed to facilitate postgraduate radiologic education, either in a self-study format or in clinical small-group tuition.

The *entity index* lets the user approach the contents by anatomic region. It is therefore particularly suitable for lecture formats and other conventional learning styles.

The *evaluation index* serves the purpose of assessing diagnostic skills. It can be used by learners for evaluating their own progress, and by teachers to gauge the success of their approach. Apart from a catalogue of questions based on cases referred by surgeons, the index provides the ELERA assessment tool (16). After registering with a user name and password, users of ELERA choose a level of challenge-and-answer cases and test questions that are selected randomly from a database. Result scores are stored under the user name, enabling long-term progress assessment. Further test and quiz programs are provided as links to external Internet sites (eg, Medpix, http://rad.usuhs.mil/medpix/menu/main_menu.html; Auntminnie; MyPACS, http://www.mypacs.net) (1).

A keyword index serves as a glossary, providing links to the relevant cases and entities.

Within the indices, cases are ordered by anatomical system and disease entity.

Navigation

The entry page (Fig. 1) is accessible from all pages via the HOME link in the navigation bar on the left and provides links to all indices within the program. The navigation bar additionally offers basic usage hints and links to a comment/feedback page and to a list of related external sites. Other navigation features are shown, depending on the index hierarchy chosen: in the case-based index, "forward" and "backward" buttons can be used to switch between cases. In the entity-based index, two pull-down menus are shown, one for the anatomic region and one for the entity. This enables the user to traverse the content hierarchy without referring back to the start page.

Copyright Permissions

The copyright for TNT-Radiology and all its components rests with the Institute of Diagnostic Radiology of the University of Erlangen-Nuremberg. Compared with most Internet information providers, we chose a liberal approach to licensing to encourage educational usage of our materials in any way the user sees fit, requiring only

proper attribution. Users therefore have a choice of copying individual images or sections of text or of downloading full pages or the entire program. To facilitate the latter, we are offering a compressed archive file of the full site for downloading. Because this is a large file (currently circa 350 MB), we recommend accessing this via a fast Internet connection.

DISCUSSION

Web-based services such as eBay, Google, and PubMed have had overwhelming success, and many of us enjoy their benefits on a daily basis. A comparable impact of Internet-based radiology education has so far failed to materialize. Reasons for this lack of impact can be found by looking at the situation of potential authors and the attitude of established (print) publishers. Existing educational Internet programs for radiology draw their support from third-party funding (2, 19), cooperations with industry (16), sponsorship through radiologic societies (3), and banner advertisement, but the most important resource remains the voluntary initiative of the respective authors. Authors can expect very little reward for their contributions in terms of remuneration and acknowledgment. Established print publishers are still largely avoiding the Internet as a medium because of perceived economic risks. The names of authors of high-quality textbooks have in some cases become brands representing that quality. This process takes years or decades; therefore, it has not been possible for anyone to develop a comparable brand "from scratch" based on Internet publications. Still, given the advantages of the Internet (14), the large number of available contributors and the potential of avoiding duplications of effort, it is to be expected that online publications will continue to gain in importance. For individual projects to be successful, it is important to meet the requirements of the largest possible audience, to design adaptability into the software, and to emphasize interactivity and customizability.

It is therefore critical to understand opinions and attitudes of the target audience and to design educational software accordingly. The purpose of this work was to determine utility criteria relevant to a large, heterogeneous group of potential users and to develop a teaching program that meets those criteria to the largest possible extent.

The result was the program TNT-Radiology. The most important distinction from other Internet programs, as well as our group's previous developments (7), is the interactive annotation. The program provides a unique density of interactive, selective annotations presented as outlines of structures in the images (20). The page layout strictly adhered to the recommendations derived from the target group survey.

Instead of being generated dynamically from a database, TNT-Radiology pages are stored statically. This means that each page has a unique, unchanging address that can be linked from other Web pages, but also from, for example, slide presentation files. This technical feature, combined with our liberal approach to copyright, matches the needs of many users, who expressed that having a local copy on hard disk or CD-ROM increased their sense of certainty about being able to access the teaching material as required. Many providers of teaching programs attempt to restrict such copying, even for private educational purposes. We believe that such restrictions are futile at best and can be counterproductive. Unlimited, free, and speedy globalization of information is a strength of the Internet that allows academic interchange to thrive for the benefit of practitioners, learners, and, ultimately, patients.

To address users' concerns about quality of teaching contents, we subject all TNT-Radiology material to a rigidly defined internal review process by one or more board-qualified radiologist. Links to external information are monitored by student collaborators. The assured quality as a source of teaching information, again combined with the permissibility of copying for academic purposes, ensures TNT-Radiology's usability as a source of visual materials. One of the benefits is that teachers can save time when preparing lectures and seminars.

A possible limitation of our study was our strategy of selecting interviewees. To collect a large amount of input, we selected predominantly by distributing requests to participate among groups that are professionally involved with radiology. It is probably safe to assume that the sample was representative of future users of TNT-Radiology, but because the sample has a strong geographic and therefore cultural skew, some of the survey results may not apply to teaching sites aimed predominantly at other countries or regions. This skew will be particularly relevant to responses having to do with hardware availability and Internet access. We expect, however, that preferences regarding layout and content quality are less culturally dependent and that our conclusions from such responses are applicable independent of location. We are aiming to collect relevant evidence by analyzing usage patterns.

Statistics on the geographic location of users, for example, will highlight if any such bias will affect the acceptance of TNT-Radiology.

We hope that our example encourages other authors of Internet teaching materials to base their efforts on a thorough assessment of their target group's needs. Apart from providing practical guidance, this approach helps to identify shared values between authors and their audience. In our opinion, this can generate a foundation of trust for success in Internet publishing. To test this assumption, we intend to monitor and assess user response to TNT-Radiology on an ongoing basis, using a similar strategy to one we previously employed in an earlier project (21).

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