Virtual Microscopy and Video-Podcasting in Medical Education at the RWTH Aachen: Analysis of the Acceptance and Learning Behavior of Students

Von der Medizinischen Fakultät der Rheinisch-Westfälischen Technischen Hochschule Aachen zur Erlangung des akademischen Grades einer Doktorin der Medizin genehmigte Dissertation

vorgelegt von
Magdalene Olga Merk
aus
Aachen

Berichter: Frau Universitätsprofessorin Dr.med. Ruth Knüchel-Clarke
Herr Universitätsprofessor Dr.phil. Dipl.-Psych. Siegfried Gauggel

Tag der mündlichen Prüfung: 9. August 2011

Diese Dissertation ist auf den Internetseiten der Hochschulbibliothek online verfügbar.
4. Results

4.1. Acceptance among students


4.1.2. Survey on virtual microscope and podcast in the MSG (2007-2010)

4.1.2.1. Subjective impression on the virtual microscope

4.1.2.2. Usage behavior and attitude towards the podcast

4.2. Analysis of server traffic on website and video server

4.2.1. Web statistics of the video podcast with blip.tv

4.2.1.1. Differences between single video episodes

4.2.2. Web statistics of the learning platform with Google Analytics

4.2.2.1. Specific traffic fingerprints depending on type of examination

4.2.2.2. Technical equipment: Hard- and software used by visitors

4.2.2.3. Geographical location and visitor loyalty

5. Discussion

5.1. Blended learning in pathology at the RWTH Aachen University

5.2. Students of the RWTH as main users of the web-based and curriculum-related content

5.3. Publishing video-based teaching content through podcasting

5.4. Usage behavior on the web-based learning platform

5.4.1. Profiles of server traffic depending on the examination

5.4.2. Frequency of use of the virtual microscope

5.4.3. Statistical differences between semesters: A matter of communication?

5.5. Monitoring changes in software and hardware of users for development towards the right direction

5.6. Acceptance of the learning platform by students

5.6.1. Virtual microscopy and annotations highly appreciated

5.6.2. Podcasting of teaching videos as support to regular courses

5.6.3. Differences between single episodes of the podcast

5.7. Perspectives

6. References

Publications

Acknowledgements

Erklärung zur Datenaufbewahrung

Lebenslauf
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHP</td>
<td>Advanced Histopathology</td>
</tr>
<tr>
<td>CNS</td>
<td>Central Nervous System</td>
</tr>
<tr>
<td>CSV</td>
<td>Comma Separated Values</td>
</tr>
<tr>
<td>DSL</td>
<td>Digital Subscriber Line</td>
</tr>
<tr>
<td>GHP</td>
<td>General Histopathology</td>
</tr>
<tr>
<td>HTML</td>
<td>Hyper Text Markup Language</td>
</tr>
<tr>
<td>ID</td>
<td>Identification</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>IQR</td>
<td>Inter Quartile Range</td>
</tr>
<tr>
<td>ISDN</td>
<td>Integrated Services Digital Network</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LM</td>
<td>Light Microscope</td>
</tr>
<tr>
<td>MC</td>
<td>Multiple Choice</td>
</tr>
<tr>
<td>MPEG</td>
<td>Moving Picture Experts Group</td>
</tr>
<tr>
<td>MSG</td>
<td>Modellstudiengang / model course of study</td>
</tr>
<tr>
<td>n.a.</td>
<td>no answer</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
<tr>
<td>OSPE</td>
<td>Objective Structured Practical Examination</td>
</tr>
<tr>
<td>RSG</td>
<td>Regelstudiengang / regular course of study</td>
</tr>
<tr>
<td>RSS</td>
<td>Really Simple Syndication</td>
</tr>
<tr>
<td>RWTH</td>
<td>Rheinisch-Westfälische Technische Hochschule</td>
</tr>
<tr>
<td>SS</td>
<td>Summer Semester</td>
</tr>
<tr>
<td>UMTS</td>
<td>Universal Mobile Telecommunication System</td>
</tr>
<tr>
<td>VLC</td>
<td>Video LAN Client</td>
</tr>
<tr>
<td>VM</td>
<td>Virtual Microscope</td>
</tr>
<tr>
<td>WS</td>
<td>Winter Semester</td>
</tr>
<tr>
<td>XML</td>
<td>Extensible Markup Language</td>
</tr>
</tbody>
</table>
Zusammenfassung


Summary

Web-based learning content plays an increasing part in the curricula of medical faculties. In the institute for pathology at the RWTH Aachen a blended learning platform is continuously complemented since 2006. The virtual microscopy comprises a collection of virtual histology samples and the podcast „PathoCast“ explains macroscopical and histological findings in compact videos, which can be watched on portable players like an iPod. Virtual microscopy and the podcast episodes represent learning units to different disease patterns, that are adapted to the courses of the „Modellstudiengang“. The learning units are published on a normal web site in curricular order corresponding to the organ systems (www.vm.rwth-aachen.de).

This work analyzes the acceptance of the blended learning platform among the students as well as their usage behavior. The subjective impressions of several years of students were assessed with surveys. The traffic on the local server of the learning platform and on the video server was continuously registered and analyzed.

The project was positively evaluated each year. Students appreciated the possibility of learning histology outside the university without temporal or spatial restrictions. Annotations on the virtual slides were found to be a highly valuable tool towards comprehension of the findings. The video podcast was appreciated for its compact illustration of relevant topics, its ability to enhance the learning fun and its effectiveness in recapitulation before examinations. The learning platform was used regularly with two different reproducible patterns in the web statistics: a) sharp peaks at the end of the respective organ system courses corresponding to short and intensive learning periods. b) plateau like profile prior to the medical basis examination, which relates to a constant elevated usage and thus learning activity during revision.

Hard- and software of the students including portable players have adapted to the ongoing product developments.

Blended learning has proved to be highly effective and attractive in teaching pathology and leads not only to the amelioration of the organ system courses but also to the independent revision prior to the medical basis examination.
1. Introduction

1.1. Computer Technology in society

1.1.1. The world wide web and its tools

The world wide web is integrated into many aspects of daily activities and work. It is no longer just a source of information generated by specialists but a platform for social networking, sharing and discussing information or opinions, buying or selling and many other activities. The presence of the internet in common life has increased and accordingly it now plays an essential role in education, at school and at the university.

In addition to websites which simply provide information for passive intake, there are also websites with web applications that allow the sharing and editing of information as well as collaboration in a user friendly environment. The tools of this interactive web, also called Web 2.0, are wikis, blogs, pod- and vodcasts, applications for video or photo sharing, social networking etc. Some of these concepts are important and should be shortly explained:

A wiki is a website that allows the easy creation and editing of any number of interlinked web pages via a web browser (Wikipedia contributors 2010). Through continuous editing, these texts may change their focus or information which can be retraced in a revision history. When citing a wiki text this problem can be solved by indicating the permanent link, which includes a Version-ID and will refer to a specific version of the article. The biggest wiki on the web is Wikipedia, a kind of online-encyclopedia.

Blogs (from Web logs) allow users to post entries which are displaced in chronological order with the most recent first. Entries are written by the same or a group of people and incorporate text, photos or videos and references or commentaries to other websites.

Podcast was initially defined as a digital recording of a radio broadcast or similar program, made available on the Internet for downloading to a personal audio player. Nowadays it is also used for distributing any kind of information divided usually in episodes which are often released in regular time periods. This is increasingly video material, so called vodcasts. Podcasts are displayed in Really Simple Syndication (RSS)-feeds that users can subscribe to.
feeds can be placed in special software as for example iTunes, with which new episodes are automatically downloaded and saved to the hard disk.

On social networking sites users create a profile which is more or less visible to others users. In this virtual community, users form an image or virtual identity and share text, photos, videos, links etc. with other members of the community. Many aspects of modern communication include chats or instant massaging, which resemble written conversations. These can also be embedded in social network web sites.

All these applications may be combined in multiple ways. Videos can be watched on video-platforms but also embedded in blogs, user profiles or other websites. Websites can be commented or recommended to others via social networks. There also is a confluence of Web 2.0 tools, for example there are Blogs with wiki functions, so called Blikis or WikiWeblogs, or a combination of social networking and a blogging service as in Twitter.

The advantages of the collaboration ware such as wikis blogs and podcasts is quick and flexible disposal of information. Users are able to create content with relatively little effort. The reduction of the needed technical skill shifts the focus to the information itself and the discourse with others respectively (Boulos et al. 2006). For lecturers this implies an independence from print publishers in providing learning material to their or other students. As the access to information proceeds in the world wide web, it can be monitored fairly accurately, thus permitting an immediate feedback to the creator of the content.

The great openness of the web applications and collaboration of many users bear the risk of a broad pool of information with no distinction between relevant and irrelevant facts. As the use of nicknames is widespread, it is often impossible to identify the author of a source. Wikis without control may be undermined by deliberate or unintended false information. Generally content which is once placed in the web, is vulnerable to reproduction without attention to copyrights.

1.1.2. Hardware

Parallel to various web applications different portable devices for playback of sound or video files have been developed. A classical example is the iPod from Apple. Podcasts or music can be downloaded to the computer and uploaded to this device, so that sound files can be heard independently from the home
computer. With video files a similar development has happened. Videos can be watched with a conventional computer, either online as stream or offline after downloading with the independence from a constant internet connection. Then there are various new portable players which can be synchronized with the content on the computer. Their compact and handy form with smaller screen sizes allows users to watch videos anywhere. Portable players or mobile phones respectively with access to the internet via UMTS also allow the replay of videos as stream without any previous transfer from a computer.

1.1.3. Web based learning

So called electronic learning or e-learning comprises different systems, i.e. Web based training systems, case studies, simulations or learning platforms. All of them are designed as interaction between the learner and a computer. Users look for the information they need themselves and the content is not necessarily attached to a curriculum of a single university.

Blended learning describes the combination of conventional teaching in the classroom with e-learning methods. The web-based courses are orientated to the curriculum and provide additional or complementary learning material to the students, which can be used to prepare and rework a course or for recapitulation before an intermediate examination. The blended learning offers ensure an interaction between students and tutors, which Wong et al. (2010) describes as highly valued by learners.

Wong et al. (2010) demands that when designing an internet-based course, attention must be given to the fit between its technical attributes and learners’ needs and priorities. A target group will accept a technology if it is easy to use and useful (as in increase of access to learning or saving time). He further names the skill of learners, course learning objectives and the availability, quality and cost of non-Internet alternatives as important contextual factors for the acceptance of a web-based course. For a course to be successful interaction has to be given.

1.2. Medical education

In medicine diagnosis usually precedes the treatment of a patient and is the requisite for an effective therapy, thus it is the central skill of every practicing doctor and has a great part in medical education. Even with modern diagnostic
equipment, many signs and symptoms are still to be found by observing the patient closely. And also the interpretation of images in radiology or macroscopic and histological findings requires a trained eye and a lot of experience. Thus students have to take in and link a lot of optical information to the respective disease patterns. This is best achieved by studying e.g. clinical symptoms on a real patient or pathological changes on real organs. However, it is impossible to cover all diseases based on conventional practical courses. This is due to the fact that patients are not always present when students need to learn the diseases and some diseases are rare, so that they might not be seen by a single student during the medical training period.

Teachers in medical education have always attempted to convey this optical information as lively as possible either by describing or drawing it very closely but also by forming or preserving 3D representations. For example Photinos (1907) highlights the optical impression colored wax models, so called moulages, e.g. of skin findings are able to provoke in students or physicians and their superiority over conventional drawings in atlases. In pathology departments formalin-fixed organs are used to teach pathological changes. An important disadvantage of formalin-fixed tissue is the loss of the original color and consistence. Moreover, some findings like a pulmonary edema can be only demonstrated on fresh tissue and are lost after the demonstration. Today many findings are documented and presented with photographs, though these lack the third dimension and the tactile impressions. An interesting alternative between photography and formalin-fixed material is the video recording of the organs before fixation. With conventional digital videos, the third dimension can be demonstrated by twisting or turning the organ whereas consistence can be shown by touching or cutting the tissue.

1.2.1. Regel- and Modellstudiengang at the RWTH Aachen

The regular course of study is divided into a pre-clinic and a clinic period with the medical pre-examination called Physikum between both periods („Regelstudiengang“). In pre-clinical semesters the normal anatomy, physiology, biochemistry etc. is taught. After the Physikum, pathology, pathological physiology and pathological biochemistry and other subjects build up on the knowledge of normal function and introduce basic knowledge of diseases, which will be seen later in subjects like surgery or internal medicine.
New approaches in medical teaching try to shift from medical education with a sequence from normal to pathological processes to an integrated multidisciplinary learning from a very early stage (Marshall et al. 2004). This multidisciplinary concept has been introduced at the Medical Faculty in Aachen since winter semester 2003/04 in a model course of study called „Modellstudiengang“.

The „Modellstudiengang“ features a different distribution of learning content as well as different teaching and examination methods. From 3rd to 6th semester the curriculum is subdivided according to organ systems. In these courses lasting 3 to 6 weeks the students learn in a compact form the different aspects of an organ system, i.e. anatomy, physiology, biochemistry, pathology with pathophysiology, as well as clinical fundamentals, pharmacology or radiology. After the 6th semester the state of knowledge is

Fig. 1 - Comparison of the „Regelstudiengang“ with the „Modellstudiengang“:
As an example the teaching about heart and vessels is shown. In the „Regelstudiengang“, cardiac functions and diseases are taught in each of the preclinical or clinical subjects. The „Modellstudiengang“ brings together all these informations in the course cardiovascular system. Internal medical or surgical topics are later deepened in the clinical semesters. While the main examinations in the „Regelstudiengang“ comprise of multiple choice questions, the „Modellstudiengang“ also uses objective structured practical examinations (OSPE).
assessed in an objective structural practical exam (OSPE), called medical basis examination, which is split into different stations representing the organ systems. The learning targets are defined in multidisciplinary curricula. This system requires a close collaboration between the lecturers of preclinical subjects (e.g. anatomy, biochemistry physiology) and those of clinical subjects (e.g. internal medicine, surgery or gynecology). The pathology is an efficient link between these different subjects, because pathological changes in organs are found in relation to the normal anatomy and physiology and provide an understanding of the resulting patients' symptoms.

This multidisciplinary didactic concept requires different learning resources as the majority of medical books still features the classical subjects with only few multidisciplinary aspects.

1.3. Education in pathology

Fundamental knowledge in macroscopic and microscopical anatomy and pathology is required for understanding organ function and disease, thus representing an essential topic matter in medical education. Moreover, increasingly high resolution techniques in imaging like in the field of radiology or nuclear medicine, require a familiarity with the morphology of diseases as a quality ensuring basic knowledge.

Macroscopic aspects are traditionally shown on the basis of formalin-fixed organs, where students can discover pathophysiological connections, e.g. the blood flow through a constricted heart valve. Microscopical findings provide a higher resolution of the pathological changes and may open a different level of understanding of clinical symptoms, e.g. malabsorption in coeliac disease is comprehensible, when the missing of villi is seen in a histological sample.

If the macroscopic and histological aspects of a disease are presented together, facultatively with a short theoretical background and clinical or radiological findings, the learning of the respective subjects is facilitated and synergistic effects are achieved. This is especially effective as part of the organ centered curriculum of the „Modellstudiengang“.
1.3.1. Learning goals and objectives in pathology

The courses in pathology should enable students and thus future doctors, independently of their specialization, to recognize organ findings in relation to the normal finding and to embed these changes in a clinical context.

Miscellaneous teaching objectives compiled by Marshall et al. (2004):
To understand and use the language of disease
To enable students to gain insights into the diseases they encounter
To show that the postmortem has a vital role in quality control and research
To introduce students to forensic science
To encourage students to think about pathology as a career choice
To convey a scientific attitude
To convey a great amount of factual knowledge
To give some practical training
To enhance the cognitive skills needed in all specialties of medicine - observation, analysis and problem solving

1.3.2. Virtual microscopy and annotations

For teaching histology, pictures have been included for decades in books and since several years also in web databases (for an overview see Böhm 2008). Teachers present preselected areas, which are usually highly significant for the disease, but do not encourage in students the process of tissue analysis. The virtual microscopy, e.g. the digitalization of whole slides, has been introduced by several universities, e.g. University of Iowa (Dee et al. 2007), University Basel (Glatz-Krieger et al. 2006b) or University Heidelberg (Sinn et al. 2008). It allows users to zoom actively into any part of it. This interaction has highly didactical values as it resembles working with a conventional microscope and encourages the students to act and learn independently. It also trains their observation and analysis skills as asked for by Marshall et al. (2004), see 1.3.1. Moreover, since digitalized slides are available at any time via Internet, users can learn and review independently of the regular lessons.

Since the process of finding diagnostically relevant areas in a slide can be quite difficult and needs experience, it is essential to highlight these areas to the students. This specially holds true for the beginning phase of learning. The aim is achieved by so called annotations, which feature different symbols like
arrows, lines, squares or circles to mark a relevant area with a corresponding explanatory text which describes the findings.

The virtual microscopy also eases some problems that arise in conventional histology training: First, often only poor-quality educational microscopes are available to the students for the analysis of conventional histological slides. This results in poor image quality and subsequent difficulties in the understanding of the findings. Second, for a high-quality practical histology course, hundreds of slides have to be cut, stained, selected, sorted and stored. This is a lot of work for a department, a logistic challenge and obviously expensive and tedious. Third, since slides have to be regularly replaced because of bleaching of the dye or simple physical damage, a large backup of paraffin-embedded tissue is required. These high maintenance efforts and costs are also described by others (Coleman 2009, Kumar et al. 2006). Fourth, highly didactic, clinically relevant and often precious small biopsies or cytological samples from pathological human tissue cannot be offered to a big group of students because it is physically impossible to collect enough single samples. The same applies to one-of-a-kind slides, which were cut in a way to show for example normal, metaplastic and neoplastic tissue next to each other (Dee 2009). Fifth, students have mostly no opportunity to visualize slides beyond the regular opening hours of the faculty.

1.3.3. Teaching with videos and podcasts

In lectures or seminars, macroscopical findings are usually presented by two-dimensional colored photographs of organs. In the internet there are several podcasts which feature pathological topics for example the audio podcasts: „Pathcast“ (University of Duisburg-Essen) or „Pathologie générale“ (University of Montreal). Others have created video podcasts, where pictures are explained with audio comments, e.g. „Pathology mini tutorials“ (University of Nottingham) or certain episodes of the „DAVE Project“ (Woosley 2006). They have the advantage of smaller file sizes (Thapa & Richardson 2010). All these two-dimensional solutions are often unsatisfactory for a realistic representation of pathological findings. It is also possible to create virtual 3-dimensional specimen, which show a static organ from every side, but cannot transport any information about the tissue texture itself (Kalinski et al. 2009).
In contrast a two dimensional but dynamic video can evoke a three dimensional understanding of an organ and its tissue consistency, when the specimen is filmed from different angles and during opening or applying of cross sections.

**Fig. 2 - Example of a more vivid presentation of findings:**
When demonstrating a heart in a dynamic video, the septum and walls can be turned over to clarify the connections and relations between the different cavities.

This optical information may be completed by descriptions of odor, findings from palpation or demonstration of criteria for differential diagnosis, e.g. membranes that cannot be wiped away. Similar to the annotations in virtual microscopy the understanding is increased when students are guided by an explanatory audio commentary which points out the important findings.

By recording tissue specimens it is also possible to present findings which normally would not be part of a student's course, for example appearance of fresh organs, which are examined in instantaneous section or organ edema, which is only visible for a few seconds after cutting the tissue. Unfixed organs often have a different tissue structure, consistency or color than formalin-fixed organs and resemble much better the in vivo circumstances in the patient.

If the processing of organs during gross examination is filmed, students gain a more accurate impression of the daily routine and the role of the pathologist in the clinical practice. (compare with 1.3.1, objectives by Marshal et al. 2004).

### 1.4. Tools for analysis of web-based teaching projects

The field of web-based medical education is very wide and heterogeneous as are to some extend the different courses of study, which makes it desirable that every course which is offered is also evaluated continuously with respect to its target group. (Wong et al. 2010)
Questionnaires are used to gather subjective impressions of the students and show the acceptance of a learning offer. They might also reveal technical problems and suggest possible enhancements.

Upon questionnaires, the objective proof of the use of a Web-based teaching project is an important part of its justification or its continued funding and an essential argument for the involvement of other teachers. Furthermore, during the development of an Internet-based project, fundamental knowledge of the technical equipment of the users as the web-browser, the operating system (OS), the screen resolution and connection speed is helpful to optimize resources and formats.

When both subjective and objective analytic methods are used synergistically, results from one may help to understand findings from the other. These analyses aim at the improvement and adaptation of the Web-based content to the needs of the conventional courses and students.

To enable a general evaluation of web-based courses, tools have to be easy to install, maintain and understand and should also be affordable.

1.4.1. Google Analytics

Google Analytics is a web-based analysis system, which is offered free of cost by Google. It is an easy-to-use program that can be operated using a conventional web browser without any specialized knowledge. Aim of this system is the optimization of the technical possibilities for commercial sites, mainly from private owners using the so-called Google AdSense links.

It can be installed to any given website by inserting a so called tracking code in the html-script. The visualization of the view statistics with a web browser (see Fig. 3) is dynamic and can be focused on certain user groups or time periods. Google Analytics also gives information about technical issues of the users, e.g. the operative system, screen resolutions of computers, Internet connections and browser used during the visits. Google Analytics operates with cookies for certain analysis, e.g. for the discrimination between new and returning visitors and the data is stored on servers from Google. Consequently users have to be informed about the analysis of a web site.
Fig. 3 - Web site of Google Analytics showing the dashboard with selected statistics: The graphic on top shows the daily visit numbers to the web site vm.rwth-aachen.de. The time period can be varied and is set in the figure to cover the whole period from the beginning of analysis in April 2007 to today (July 2010). On the left, different options for analysis are listed.

1.4.2. Videoserver and view statistics
The web site is hosted by blip network incorporated in New York (www.blip.tv). It permits the independent creation of a web show by uploading videos in different formats. Video-shows can be linked as RSS-Feed and so viewed as podcast on e.g. iTunes. In contrast to YouTube, a similar widely used video platform, blip.tv enables users to download videos and supports a file format that is compatible with portable players like an iPod. The access to the videos is tracked so that the show creator can follow the statistics and charts over time by downloading a Comma separated value (CSV) -data sheet or by viewing the last four months in html-format.
The show "PathoCast" has no restricted access for users. In 6A the video "aortic valve sclerosis" is opened as an example. The statistics may be as seen by the show creator after login. In 6B the cumulative number of views to each post is shown. A html-display of daily view numbers over the last 4 weeks is also possible.

Fig. 4 - Screenshots from the videoserver www.blip.tv:
2. Objectives

The main goal of this work is the evaluation of four years of blended-learning in pathology at the RWTH Aachen University. For the evaluation, both subjective impressions from the students gathered by surveys and objective measures as the traffic on the local server of the learning platform and on the video server were systematically analyzed.
Several questions arise when planning and developing internet-based teaching platforms:

How often and how intensively do students use the platform?
Do students integrate the content in their normal learning schedule?
Does the click-behavior change over time?
Is click-behavior dependent on the exams?
Is a password-free blended-learning platform also significantly used by students of other universities?
Does the platform thus require restricted access?
How do students rate the different features of the platform?
Are the technical requirements of the platform adapted to the hard- and software of the majority of the students?
Are internet-based teaching methods as well accepted as books?
How can the content be improved to optimize learning processes and also fun?

The subjective and objective evaluation of internet-based content will help to understand learning behavior of students and their needs in medical education.
The permanent development and adaptation of the content is essential for the success of modern learning projects.
3. Material and Methods

3.1. Development of the web-based learning platform

The construction of the web-based learning platform took by Dr. Alberto Pérez-Bouza place in several steps. First, in June 2006 the virtual microscopy was established and a collection of virtual slides was allocated on a web server with open access. Second, to facilitate the navigation through the slides and in order to track visits, a web site with links to the slide collection or to single slides was created. In a third step, a video podcast, named „PathoCast“ was established in October 2007. These learning videos explain diseases from the macroscopical and histological point of view and also include radiological findings or further information like symptoms or clinical findings. They are published on the video server blip.tv, which can be linked as RSS-Feed. Thus, videos are also viewable with iTunes or portable players like the iPod. For an effective learning environment, virtual microscopy and video podcasting were combined in March 2009 (www.vm.rwth-aachen.de).

Fig. 5 - Design of the web site www.vm.rwth-aachen.de and of a learning unit (gastritis): The screenshots show the structure of the web site. From an overview over the organ systems the user gets to the list of diseases and then to the respective learning unit (here gastritis A, B and C). The video of the learning unit is embedded as cross link to the podcast and can be
The web site was reconstructed and the video episodes were embedded into so called learning units which also link to the virtual slide collection. According to the structure of the „Modellstudiengang“ these learning units are grouped into organ systems such as „respiratory system“, „gastrointestinal system“, „cardiovascular system“, etc. Via the top bar it is also possible to directly access the whole collection of virtual slides or the podcasts RSS feed. A web page on the project encourages students to leave comments or praise and includes the notice, that the web site is analyzed by Google Analytics for research purposes.

3.1.1. Virtual microscopy

3.1.1.1. Digitization and release of histological preparations

The histological preparations were scanned with a slide scanner (Aperio CS) using a 20x objective, which was found to be sufficient for most preparations (Sinn et al. 2008). For small biopsies or cytological samples, a 2x lens was added to reach the 40x magnification (so called “doubler”). Digitalized slides were uploaded to a Microsoft web server together with the annotations through Web-based Distributed Authoring and Versioning (WebDAV) and located in different folders sorted by organ systems (e.g. cardiovascular, respiratory or gastrointestinal system).

The access to the slides and folders is gated through the relatively universal port 8080 (Fig. 6, dashed-lined box). Higher ports can create conflicts with some firewalls, especially within networks of hospitals or universities.

Visualization of the slides is based on flash-software and slides are administrated by a server software (Webviewer, Aperio). Any available Internet-browser with a plug-in Flash-player (Adobe) is able to visualize the slides without restrictions. Each folder and each slide has its own link, derived from the server port + folder name + slide name. Example: http://vm.rwth-aachen.de:8080/gastrointestinal tract/gastritis.

Since the generation of Web-compatible digital slides by the software Webviewer occurs only on demand, Google or other Internet search engines cannot find it by any key word. Thus, a conventional website was built that directly links to the folders containing the slides or, if necessary, directly to the
Fig. 6 - Schematic overview of web-based microscopy at the RWTH Aachen University: Slides are stored on a server in a classical folder-tree and visualized on demand in apml-format with the server software "Webviewer". The representation of the slides is gated through a server port (in this case the port 8080). Because the slides are visualized on demand as apml-format, search engines like Google cannot find the single folders or slides. To allow Google, and thus users, to find the educational material, a conventional website was built with links to the content of the server.

3.1.1.2. Layout and annotation of slides

Folders and single slides are represented as an icon (thumbnail) with a written title (Fig. 7A). The software Aperio-Webviewer controls the visualization of the folders and single slides by building a Webpage on demand with a standardized layout (Fig. 7). Slides are grouped in folders and sub-folders, which are defined by the teacher (Fig. 7A).
Material and Methods

Fig. 7 - Screenshots of a representative folder-tree (A) and of a single slide in maximal resolution (B):
The layout is self-explaining and resembles the icons of a classical computer. With a link, the user can return to the folder. Each histological slide is represented by a linked icon or thumbnail, which opens the slide. Single slides are represented in a standardized manner (B): A title on the top (file name), an overview (navigator) on the upper right hand-side, customized logos on the upper left hand-side, and magnification-commands on the bottom. Relevant areas are marked with circles, squares, arrows etc. The corresponding text is shown on the bottom of the slide and the link in the annotation list on the right side.

On single slides, an overview (navigator) remains on the upper right-hand side for orientation (Fig. 7B). At the bottom of the picture, the main commands permit intuitive control of magnification as well as horizontal or vertical movements of the slides. Alternatively, slides can be moved by click-and-drag and the magnification can be changed by double-click. The logos on the upper left-hand side can be configured and changed by the user.

Annotations of the slides are written and placed with the software Scanscope (Aperio) and uploaded as xml-data to the server (Fig. 6). The circles, squares or arrows as well as the explanatory text are represented as an overlay on the
virtual slide. On the right-hand side of the slide, the links to the different regions of interest are listed in vertical manner (Fig. 7B). The user can choose between showing or hiding the annotation links. When the region-links are hit, the correct magnification, in which the annotation was made, is shown. At the bottom of the slide (Fig. 7B) the corresponding text appears.

3.1.2. Video production and podcasting

3.1.2.1. Didactical composition

The videos comprise animated presentations with histological drawings, pathophysiological explanations and correlations to clinical or radiological findings. The organ with or without pathological changes is shown as gross specimen and histological sample. Some videos focus on key features for the differential diagnostic of for example gastritis A, B and C, Crohn’s disease and ulcerative colitis, lipoma and liposarcoma or small cell and non small cell lung carcinoma. Other videos integrate topics of general pathology like inflammation, which is part of the video „pneumonia“ or granuloma formation in „gout“. The videos have a length of 2 to 20 minutes depending on the complexity of their content. Longer videos are divided into chapters, which allow the instant look-up of a certain sub topic (compare Figs. 8 and 9B).
Fig. 8 - Screenshots of the video „Crohn’s disease vs. ulcerative colitis:
The two disease patterns are presented with a theoretical background and pattern of distribution (A), a schematic representation of the histology (B), macroscopical changes (C) and microscopical findings (D). The video is subdivided into chapters (bold arrow in A) to enable selective replay of single topics.

3.1.2.2. Technical realization
The videos were processed using an Apple-Computer (iMac 20") and its representative software (iLive 2006 and 2008). Similar software solutions exist for the Windows operating system.
Fresh or formalin-fixed organs were filmed with a customary digital camera with video function. A Nikon Coolpix 3700 with a resolution of 640x480 pixel was used for most videos and some were produced using a high definition digital camera (Canon HV30) with a resolution of 1280x720 pixel.
The presentation of the virtual microscopy material was realized by screen casting with the software iShowU. Similar to screenshots, a video is recorded of what is happening on the screen, e.g. the examination of a virtual slide.
Schematic drawings of histological features and short explanations in note form were animated in the program Keynotes (similar to PowerPoint in Windows-OS) and than exported as a video. The texts for the audio commentaries were written according to the learning targets in the curriculum and recorded with a digital dictaphone (Olympus LS-10).
The audio and video files were merged in iMovie (iLive 06 or 08), edited and exported as mv4-format in a resolution of 640x480 pixel. A similar approach is described by Whitehead et al. (2007). Extensive videos with a length of up to 20 minutes were subdivided into chapters with the software Simple Movie X.

3.1.2.3. Publication
The mv4-format of the videos ensures a compatibility with portable players like iPod or iPhone. The videos were released on the video server blip.tv as episodes of an individual show or podcast named „PathoCast“. (www.pathocast.blip.tv). After a video was uploaded to the web site, the video platform automatically generated a flash version of the file, which was displayed in a web browser. Simultaneously the video was added to the Really Simple Syndication (RSS)-Feed of the podcast and subscribers automatically received the newest episode. The RSS-feed was linked in iTunes and since 2008 in iTunes-University of the RWTH Aachen University.
This way of publication enables different possibilities of access to the content. Students can watch the videos online with a web browser, download and store them on their hard disk or transfer them to a portable player. Videos are ordered chronologically but have tags related to the content or to the organ system to which they belong, so that they can be easily grouped using the search function of iTunes.

3.2. Methods of analysis

The objective use of the learning platform was monitored simultaneously by analysis of the access to the videos and the web site over a total time period of 3 years. The subjective impressions of the students were recorded with conventional surveys at the end of the semesters. The different methods of analysis are outlined in figure 10. Two different questionnaires were used for evaluating the virtual microscope (questionnaire 1 for the „Regelstudiengang“) and the virtual microscope with the PathoCast videos (questionnaire 2 for the „Modellstudiengang“). The analysis of the access frequencies started in june 2007 with Google Analytics and was augmented in october 2007 with the registration of the view counts on blip.tv.
Methods for analyzing the virtual microscopy and the video podcast over time:

Students of the „Regelstudiengang“ (RSG) were asked to evaluate the use of the virtual microscope (VM) in the courses „general histopathology“ (GHP) and „advanced histopathology“ (AHP). Students of the 3rd semester in the „Modellstudiengang“ (MSG) rated the use of the virtual microscope (VM) and the video podcast (PC). The data of questionnaire 1 (Q1) and questionnaire 2 (Q2) were pooled separately (grey boxes). Google Analytics was installed for the analysis of the website to the virtual microscope in June 2007 and the first videos were released in October 2007 (grey arrows).

3.2.1. Survey on the virtual microscope in the RSG (2006-2007)

Three different groups of students between the 3rd and 5th year of medical education participated in the courses of general and advanced histopathology at the Medical Faculty in Aachen between May 2006 and July 2007. In each course students received a box containing 30 or 40 glass slides with histological preparations (general and advanced histopathology, respectively). Every student had access to light microscopes not only during the courses, but also additionally twice a week for additional three hours.

On a voluntary and anonymous basis, students filled out a questionnaire (Q1) with 19 questions for the evaluation of the digital microscopy. It was filled out just before the examination by a total number of 192 students.

The questions covered general information about the user and his technical equipment (questions 1-6) as well as learning behavior (questions 7-9). In questions 10-19 students rated different aspects of the virtual microscope by giving points from 1 to 10, according to their subjective impression.
Items in Q1:

**General:**
1. How long have you been at the Medical Faculty?
2. Gender?
3. Do you have a computer?
4. Which operating system do you have?
5. Which Internet connection do you usually have?
6. Which web-browser do you usually use?

**Learning behavior:**
7. Where do you prefer to use the virtual microscope? (home, faculty)
8. How often do you use the virtual microscope? (daily, 1-2x per week, 1-2x per month, sporadically)
9. How long are the sessions using the virtual microscope on average? (more than 60 minutes, 30-60 min., 15-30 min., 5-15 min., less than 5 min.)

**Subjective impression:**
10. How do you rate the handling of the virtual microscope? (1= complicated, 10= self-explanatory)
11. How do you find the image quality of the virtual microscope compared to the conventional light microscope? (1= much worse, 10= much better)
12. How do you find the handling of the virtual microscope compared to the conventional light microscope? (1= much more difficult, 10= much easier)
13. How important is it to include annotations on a virtual slide? (1= irrelevant, 10= very important)
14. How important is the virtual microscope as an additional offer? (1= irrelevant, 10= very important)
15. How important is it to have an all round available Internet-based solution? (1= irrelevant, 10= very important)
16. Has the virtual microscope facilitated learning histology? (1= not at all, 10= much easier)
17. How important is it for you to be able to analyze whole digital slides compared to single pictures? (1= irrelevant, 10= very important)
18. Do you find the virtual microscopy adequate for examinations? (1= not at all, 10= very adequate)
19. Did you enjoy learning with the virtual microscope? (1= not at all, 10= very much)

The data of the three student groups, who filled out questionnaire 1, were pooled (see Fig. 10) and questionnaires, which were not fully completed, were also analyzed (category: no answer = n.a.). The answers to the general questions (1-6) were calculated in relative frequencies, as were the answers concerning the learning behavior (7-9) and represented as diagrams. As the distribution of answers concerning the subjective impressions (10-19) is highly asymmetric, the median, upper and lower quartile were calculated in addition to the arithmetic mean. These distribution data were visualized in box-plots for each question (Fig. 13B). A cross represents the arithmetic mean, a grey box equals the interquartile range (IQR) with the thick line marking the median. The whiskers show data in the range of 1,5 x IQR below (and above) the lower (and upper) quartile and the circles correspond to outliers.

3.2.2. Survey on podcast and virtual microscope in the MSG (2007-2010)

Three consecutive years of students who participated in the course „cardiovascular system“ in their 3rd semester were asked to fill out a questionnaire voluntarily and anonymously. The questionnaire was dealt out and collected during the breaks of a 4-hour revision lecture, that took place a few days before the examination. The first two cohorts were surveyed in the same year (February 2009), meaning that the course WS 2007/08 was evaluated retrospectively (see Fig. 10). In questionnaire 2 most items were statements to which students could agree or disagree on a 7-points-scale, similar to Likert-scales.

Example: Learning with PathoCast was fun.

                      disagree 1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( ) agree
In contrast to questionnaire 1, where the rating points were written down as a number, in questionnaire 2 they are checked on a visual, equidistant scale. A midpoint was included, so abstentions or indifference to a statement were possible. The items covered three different learning offers: the podcast, the virtual microscopy and the video recording of lectures, whereas the latter will not be discussed in this work. Questions focused on usage behavior and
students attitude towards the offers. In the section on PathoCast open-end questions concerning the topics of the different episodes were asked additionally (questions 7.-9.). Each section ended with a general rating and an invitation to comment freely.

**Items in Q2:**

**General:**
1. Gender?
2. Do you have an iPod? If yes, which model?

**PathoCast:**
3. How often did you use PathoCast? (1= very little, 7= very frequently)
4. How did you watch the PathoCast episodes preferably?
   - on the web via blip.tv (1= not at all, 7= exclusively)
   - with iTunes (1= not at all, 7= exclusively)
   - on an iPod (1= not at all, 7= exclusively)
   - via vm.rwth-aachen.de (1= not at all, 7= exclusively)
   - others
5. Did you use the chapter division? (Yes; No)
6. The episodes of 15 to 20 minutes are too long even with chapters. (1= agree, 7= disagree)
7. Which PathoCast episode(s) do you rate especially successful and why?
8. Which PathoCast episode(s) should be especially improved and why?
9. I would have liked PathoCast episodes on the following topics:
10. PathoCast has contributed to an effective revision. (1= disagree, 7= agree)
11. Learning with PathoCast was fun. (1= disagree, 7= agree)
12. Please rate PathoCast overall! (1= bad, 7= very good)
13. In your opinion, could this way of teaching (multimedia, virtual microscopy, e-learning) only supplement classical medical books or could it even replace them? (1= supplement; 7= replace)
14. Comments

**Virtual microscopy:**
15. How often did you use the virtual microscopy? (1= very little, 7= very frequently)
16. The virtual microscopy has contributed to an effective revision. (1= disagree, 7= agree)
17. I would like to diagnose virtual slides first without further information and compare my diagnosis with the correct solution. (1= disagree, 7= agree)

18. The so called „annotations“ (markers on the image) in the virtual slides were helpful. (1= disagree, 7= agree)

19. The virtual microscopy as it is now was fun. (1= disagree, 7= agree)

20. Please rate the virtual microscopy overall! (1= bad, 7= very good)

21. Comments

The data of the three student groups, who completed questionnaire 2 were equally pooled (see Fig. 10) and a category „no answer“ was included in the results. The answers to questionnaire 2 were visualized as relative frequencies for each winter semester in bar charts. The pooled frequencies of all three years are also shown on top of the respective group of bars (Figs. 14-16).

In question 4 each option could be rated with 1 point (not at all) to 7 points (exclusively). To simplify the results, all answers from 2 to 7 points were rated as „the option was used“, whereas no answer and 1 point were defined as „the option was not used“. To preserve the relation between 2 and 7 point answers, the points were included as factor, where e.g. 7 points equal a full exclusive use and 4 points equal a partially exclusive use, diminished by the factor 4/7th (see Table 1, column C). The calculation is shown on the basis of an example from the WS 2009/10 with n=170 students:
3.2.3. View counts of the podcast episodes with blip.tv

The numbers of views of different videos are automatically recorded by the video platform blip.tv. Every access to a video is protocoled with date and time, referrer (e.g. iTunes or cross link to vm.rwth-aachen.de) and browser of the user. This data was exported as „raw view counts“ in csv-format, the file was converted into an Excel-Sheet and daily access numbers were calculated using the function „FREQUENCY“. The date and time column used for the calculation was formatted as „number“, which is defined in excel for windows as x days after the 1.1.1900. (see Fig. 11A column G:G) The daily views were then charted over time.

Table 1:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>points</td>
<td>iTunes</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>n.a.</td>
<td>56</td>
<td>not used</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>6</td>
<td>1,7</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1,3</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>2</td>
<td>1,1</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>8</td>
<td>5,7</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>15</td>
<td>12,9</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>sum 56,7</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>% 33,3</td>
<td></td>
</tr>
</tbody>
</table>

Column C is calculated as follows:

C4 = B4 x A4 / 7
Material and Methods - 27

The daily view frequencies were analyzed for all videos and for certain groups, e.g. only videos of one organ system or only videos that were watched via the cross link on the web site vm.rwth-aachen.de.

In a given time period, e.g. the learning phase prior to the medical basis examination, the absolute number of accesses to every video episode was...
calculated and compared to the mean number of accesses of a single episode and its standard deviation.

3.2.4. Visitor statistics for the web site with Google Analytics

The set-up of Google-Analytics requires a Google user account. A single so called tracking code is provided which has to be inserted in the HTML-script of every web page to be analyzed. The following code was inserted before </body> into the HTML-script of the entry web page of the web site:

```html
<script src="http://www.google-analytics.com/urchin.js" type="text/javascript">
</script>
<script type="text/javascript">
try {_uacct = "UA-single user code"; urchinTracker();} catch(err) {}</script>
```

The "UA-single user usercode" is individual for every Google-Account. Only individuals with access to the HTML-script of the web pages are able to insert the tracking code. Once the analysis system is set up by inserting the java script code into the HTML-pages, the recording of the data occurs automatically. The possibilities of analysis provided by Google-Analytics are very various. In the present study following aspects were examined:

- Number of visits per day
- Operating system
- Browser
- Internet Connection speed
- Screen resolution (number of horizontal and vertical pixel)
- Screen format derived from the screen resolution
- Visitor loyalty (number of returning visitors)
- Geographical location

3.2.5. Time periods for web statistics

The web statistics are focused on two specific periods of time during three successive years which are specified in table 2: three different winter semesters from october to february are shaded in grey and two different summer semesters from april to september are shaded white.
During the winter term between October and February, the classes involving the department of pathology are the musculoskeletal, cardiovascular, gastrointestinal and genitourinary systems. Each course is composed of approximately 2 months of intensive multidisciplinary teaching followed by a written or oral examination. The courses have a defined length and are repeated in the same pattern for every new year of students.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15.10.07</td>
<td>07.04.08</td>
<td>13.10.08</td>
<td>06.04.09</td>
<td>12.10.09</td>
</tr>
<tr>
<td>End (Sunday)</td>
<td>17.02.08</td>
<td>14.09.08</td>
<td>15.02.09</td>
<td>13.09.09</td>
<td>14.02.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of students</th>
<th>3rd Semester</th>
<th>200</th>
<th>197</th>
<th>263</th>
<th>260</th>
<th>234</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of students</td>
<td>5th Semester</td>
<td>251</td>
<td>250</td>
<td>228</td>
<td>213</td>
<td>259</td>
</tr>
<tr>
<td>Total No. of</td>
<td>students</td>
<td>451</td>
<td>447</td>
<td>491</td>
<td>473</td>
<td>493</td>
</tr>
</tbody>
</table>

Table 2 - Time periods for analysis and numbers of students:
Each time period comprises whole weeks and starts with the beginning of the semester. The numbers of students in each semester are relatively constant, with a total number of 450 to 500 students in their 2nd or 3rd year.

During the winter term between October and February, the classes involving the department of pathology are the musculoskeletal, cardiovascular, gastrointestinal and genitourinary systems. Each course is composed of approximately 2 months of intensive multidisciplinary teaching followed by a written or oral examination. The courses have a defined length and are repeated in the same pattern for every new year of students.

<table>
<thead>
<tr>
<th>Week in Semester</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd Sem.</td>
<td>musculoskeletal system</td>
<td>interdisciplinary courses</td>
<td>cardiovascular system</td>
<td>respiratory s.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th Sem.</td>
<td>psyche</td>
<td>gastrointestinal system</td>
<td>genitourinary system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examinations: OSPE, OSPE, written exam

Fig. 12 - Courses in winter semester for 3rd and 5th year students:
The courses and examinations always take place in the same weeks of the semester, facilitating the comparison between different years of students, e.g. when analyzing views per day.
In the summer term between April and June the content of the blended learning platform comprises the course „respiratory system“. Other courses like „nervous system“ or „blood and immune system“ are not yet included in the platform. In the holidays between July and September, students of the 3rd year prepare for the medical basis examination. In this period of time, no lessons are offered but unrestricted access to the web content is warranted. The examination includes ten different organ-units and testing comprises of an OSPE parcours and an additional written exam.

The data on the video views from blip.tv is generally analyzed for the 3 successive winter semesters. A specific examination of the cross linked videos is done for the period after june 2009, when the videos were embedded into the website. This time span includes the medical basis examination autumn 2009 and the winter semester 2009/10.

The data from Google Analytics, daily visit numbers as well as all other parameters, are looked into for the same 3 winter semesters as well as the 2 summer semesters in between with the following medical basis examination.
4. Results

4.1. Acceptance among students


Questionnaire 1 was filled out by the students of the regular course of study after the course „advanced histopathology“ in the summer semesters 2006 and 2007 (n=118 and n=45) as well as after the course „general histopathology“ in the winter semester 2006/07 (n=29). From a total of 192 participants the majority of the students were in their 4th or 5th year at the medical faculty (3rd year: 13%, 4th year: 50%, 5th year: 22% and beyond 5th year: 12%, n.a.: 3%). 55% were female and 45% were male. Nearly all students had their own computer (98%) with mainly windows as operating system (Windows XP: 85%, Windows 2000: 9%, Windows 98: 5%, Macintosh OS: 1%). The Internet connection used was mainly a high speed connection (DSL: 54%, LAN: 29%); only a small group used a modem (10%) or ISDN (4%). The main browsers used for the microscopy were the Internet Explorer (59%) or Firefox (31%).

The results of the survey regarding learning-behavior are resumed as diagrams in figure 13A. The vast majority of the students used the virtual microscope at home (89%), while less than 10% accessed it at the faculty. Prior to the exam 75% of the students used the virtual microscope at least 1-2 times per week or even daily. Nearly 50% of the students spent more than one hour with the virtual microscope in one session, 22% between 30 and 60 minutes and 16 % between 15 and 30 minutes.

Figure 13B depicts the results of the subjective impressions as box-plots. Students found the handling of the virtual microscope (VM) self-explaining with a mean of 8,4 points out of 10 (median 9). Compared to the conventional light microscope (LM), the image quality of the virtual microscope was rated slightly better (mean 7,1; median 8), while the handling was considered nearly equally easy or difficult (mean 6,1; median 6). However the answers to these two questions are rather broadly distributed.

The importance of the virtual microscope as additional didactic offer and the constant availability of the histological section on the Web was highlighted by mean scores of 8,5 and 8,7 points respectively. Further important features for the students were the possibility of the active analysis of whole digital slides...
(mean 8.7) as well as the presence of the annotations on the slides (mean 9.1). For the majority of students the virtual microscope facilitated learning of histology (mean 7.2), most considered it adequate for examinations (mean 6.5) and learning with the virtual microscope was generally considered fun (mean 7.2).

**Fig. 13 - Results of questionnaire 1 in the Regelstudiengang:**

13A Results of the survey show that students use the virtual microscope intensively. The majority of the students learn online daily or once or twice a week. In each session, more than 50% of the students work for longer than one hour during a single session. The favorite place to learn with the virtual microscope is at home.
4.1.2. Survey on virtual microscope and podcast in the MSG (2007-2010)

In the three consecutive years WS 2007/08, 2008/09 and 2009/10 200, 263 and 234 students participated in the course cardiovascular system. Of these 130, 196 and 170 students returned the questionnaires. The overall response rate was 71%. Of the total 496 participants 56% are female and 27% male.

4.1.2.1. Subjective impression on the virtual microscope

As shown in figure 14 the answers to question 15. and 16. about the virtual microscope are broadly distributed. Most students (25%) rated their use intensity with 5 points and 22% indicated a frequent use (6-7 points). 53% of students agreed with 5-7 points to the statement that the virtual microscopy had contributed to an effective revision before the exam, while 30% disagreed (1-3 points).

Many students would like to diagnose virtual slides first without further information and compare then their diagnosis with the correct solution (Fig. 14, 17.); 58% agreed with 5-7 points. During the three years the numbers in favor of this self-assessment option decreased slightly, but some students supported the idea strongly in the free comments.

The annotations were considered very helpful (7 points) by 67% of the students and helpful (5-6 points) by 28% (Fig. 14, 18.). In the free comments many students wished for an extension of the annotations to more virtual slides in the collection. 62% of the participants agreed that the virtual microscope was fun to use (5-7 points), though the majority (25%) gave 5 points (Fig. 14, 19.). Overall 88% rated the virtual microscope as good between 5 and 7 points with 42% indicating 6 points (Fig. 14, 20.).
Fig. 14 - Subjective impressions of the virtual microscope in general and during revision:

The bar charts depict the distribution of ratings as relative frequencies for each year with the pooled frequencies on top of the bars. The usage among students is inhomogeneous from 18% who use the virtual microscope very little to 22% who use it frequently. A similar broad distribution of answers is seen concerning the benefit during revision and the fun. A possibility to diagnose slides oneself is appreciated by 58% of the students while the annotations are clearly highlighted as helpful by 92% of the students.
4.1.2.2. Usage behavior and attitude towards the podcast

The results of three different student groups (winter semester 2007/08, 2008/09 and 2009/10) are shown in figures 15 and 16.

![Graphs showing usage behavior](image)

Fig. 15 - Result of the survey about the podcast “PathoCast”:
The bar charts depict the distribution of answers as relative frequencies for each year with the average on top of the bars. The students in WS 2007/08 and 2009/10 indicated a more intensive use than the students in WS 2008/09 while overall 46% were frequent users (6-7 points). Most students watched the videos on the web or with iTunes until the web site vm.rwth-aachen.de integrates videos in March 2009 and accounts for 38% of views (adjusted percentages, see material and methods, 3.2.2). Half of the students used the chapter division and most did not rate a length of 15-20 minutes for the videos as too long.

46% of all students rated the intensity of their PathoCast use with 6-7 points, while 16% gave 5 points. In the winter semester 2008/09 the use of PathoCast was significantly lower (Fig 15, 3. see also discussion).

Multiple responses were possible to question 4 about replay options and the percentages were related to the exclusivity of use (see Material and Methods 3.2.2) In the winter semesters 2007/08 and 2008/09 the podcast was visualized mainly via the video server blip.tv (47%) and via iTunes (41%). In winter semester 2009/10 the videos had been embedded into the learning units of
vm.rwth-aachen.de and 38% of the students chose this way to watch the videos, while 37% used the video server and 33% iTunes (multiple answers were possible). The usage of iPods was relatively low in the first two years with 9% and 8% respectively and increased to 15% in the third year. Accordingly the number of students who had an iPod rose from 35% in WS 2007/08 to 39 % (WS 2008/09) and 45% in WS 2009/10. The most indicated model in the WS 2007/08, 2008/09 and 2009/10 was the iPod Nano which 22%, 26% and 23% possessed. The iPod nano has a small screen and is not ideal for watching video podcasts. The number of students who had an iPod with more suitable screen sizes increased over the 3 years (Classic (6%, 5% and 9%) and Touch (4%, 3% and 9%)). An iPhone was possessed by constantly 2% of the students (question 2, results not shown in a figure). As other tools for replay students mentioned: Mobile phones with video functions, mp3-Players, Playstation 3 and the computer with other media players (Windows Media Center, VLC player). The chapters were used overall by half of the students with an upward trend towards the last year (Fig. 15, 5.). For two thirds a length of the video episodes of 15 to 20 minutes was not too long (points 1-3), regardless of whether the chapters were used or not. Overall 13% were indifferent (4 points), with a higher percentage among those, who did not use the chapters (Fig. 15, 6.).
As depicted in figure 16 (10.) 70% of the participants felt, that the podcast had contributed to an effective revision (5-7 points) and some commented, that the videos allow a "targeted" and "economical" preparation for the exam and a "consolidation of the subject matter". The fun was rated with 5-7 points by 86% of students (Fig. 16, 11.) and was also mentioned several times in the free comments. For questions 10. and 11. students in WS 2008/09 gave generally less points than the other two cohorts. Overall the podcast „PathoCast“ was rated very good: 89% gave 6 or 7 out of 7 points (Fig. 16, 12.).

As depicted in figure 16 (10.) 70% of the participants felt, that the podcast had contributed to an effective revision (5-7 points) and some commented, that the videos allow a „targeted“ and „economical“ preparation for the exam and a „consolidation of the subject matter“. The fun was rated with 5-7 points by 86% of students (Fig. 16, 11.) and was also mentioned several times in the free comments. For questions 10. and 11. students in WS 2008/09 gave generally less points than the other two cohorts. Overall the podcast „PathoCast“ was rated very good: 89% gave 6 or 7 points (Fig. 16, 12.).

A fifth of the students agrees, that this kind of teaching could replace classical medical books (5-7 points), while the majority of 65% sees these methods as supplement to the present text books (Fig. 16, 13.). In the free comment many students supported an extension of the teaching concept to other subjects or lecturers.
4.2. Analysis of server traffic on website and video server

Both analysis systems operated continuously stable and the data recording was reliable and showed no interference with the speed of the server or computers of single users. Google-Analytics converted the raw data to diagrams and graphs, which are presented in HTML-format (for a screenshot of the dashboard, see Fig. 3) The analysis of different subsets of data, for example a certain time period or the visits of users with a certain hardware is effortless and quick to implement.

The processing of the exported raw view counts, which were exported from the video server blip.tv, is time consuming and each change in parameters for the analysis requires a new calculation. As the raw data is easily accessible there are many possibilities of graphical visualization, while in Google Analytics screenshots are taken of the given graphs.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>total no. of students</td>
<td>451</td>
<td>447</td>
<td>491</td>
<td>473</td>
<td>493</td>
</tr>
<tr>
<td>total no. of visits to the web site</td>
<td>8.965</td>
<td>6.622</td>
<td>8.542</td>
<td>7.006</td>
<td>8.077</td>
</tr>
<tr>
<td>total no. of views of the videos</td>
<td>16.144</td>
<td>19.263</td>
<td>26.819</td>
<td>28.394</td>
<td>60.106</td>
</tr>
</tbody>
</table>

Table 3 - Total numbers of access to videos and web site with respective numbers of students in each year:
The visits to the web site are relatively stable with a total count between 8000 and 9000 visits per winter semester. In contrast the views of the videos rise exponentially, suggesting the use by other people outside the faculty.

Table 3 resumes the visits to the server, the views of the videos and the respective number of students in each winter semester between the years 2007 and 2010. There is little variation in the number of students and visits to the web site between the different years, suggesting a specific use by the students of our faculty. In contrast the views of the podcast videos increase exponentially from year to year. Overall since the introduction of the podcast until august 2010 the 35 videos had together 220.452 views.
4.2.1. Web statistics of the video podcast with blip.tv

The daily view counts for the podcast episodes are graphed in figure 17 over three consecutive winter semesters, in which the frequency of daily views rose with every year.

![Graph showing daily view counts for three winter semesters](image)

**Fig. 17 - Daily view counts (y-axis) of the podcast during 3 winter semesters (x-axis):**

Two main peaks in each year correspond to the courses gastrointestinal system and cardiovascular system with the dashed lines marking the examinations at the end. The basal view counts between the courses rise with every year and the peaks are getting less definable.

The two main peaks, which are repeated in every winter semester, occur during the courses gastrointestinal system and cardiovascular system (Fig.17). These peaks increased from a maximum of 660 views per day during the course gastrointestinal system in WS 2007/08 to a maximum of 2299 views per day
during the course cardiovascular system in WS 2009/10. The baseline between the courses is becoming more turbulent over time and the mean daily visits rise from about 60 views per day in WS 2007/08 to approximately 300 views per day in WS 2009/10.

Selected view statistics from SS 2009 and WS 2009/10 which focus on the views via cross links on the website vm.rwth-aachen.de reveal a clearer pattern:

![Figure 18 - Access to the podcast episodes via cross links from the learning platform](image)

Fig. 18 - Access to the podcast episodes via cross links from the learning platform:
Daily view counts (y-axis) are graphed over time (x-axis). The baseline is nearly zero and a clear pattern is visible for the revision period before the medical basis examination (grey line) as well as the short learning phases before the exams at the end of each course (dashed lines).

In figure 18 the views during the revision for the medical basis examination form a clearly marked of plateau with a slight enhancement at the beginning and end of the learning period (20.7.-8.9.2009). The mean daily views are 59 per day (compared to a baseline of about 3 views per day before). In the winter semester the profile of daily views becomes more sharp with a strong, exponential increase to a maximum of 284 view per day in the course „gastrointestinal system“ and 373 daily views in the course „cardiovascular system“. A rapid decrease in view counts follows with examinations (marked with dotted lines).
### 4.2.1.1. Differences between single video episodes

During the 51 days revision period prior to the medical basis examination in September 2009 each video was viewed on average 102 times. Figure 19 depicts which videos were watched above average and which below. Three videos are outside the range of +/- one standard deviation: „Aortenklappe: Normalbefund und Stenose“ (aortic valve: normal and stenosis) with a maximum of 266 view counts, „TNM Klassifikation“ (TNM classification) with 43 views and „Normales Herz“ (normal heart) with a minimum of 31 views.

![Fig. 19 - Comparison of single video episodes during revision](image)

**Fig. 19 - Comparison of single video episodes during revision:** Depicted are the total view counts (x-axis) for every video episode during the revision period for the medical basis examination (20.7. - 10.9.2009). The average view count for a video is 102 views (thick line) with a standard deviation of 43. The dotted lines mark the range of +/- 1 standard deviation (59-145 views).
4.2.2. Web statistics of the learning platform with Google Analytics

4.2.2.1. Specific traffic fingerprints depending on type of examination

The recording of visits per day over time showed two different patterns in the specific periods, depending on the different types of examinations.

The daily visits between October and February of the winter semesters 2007/08, 2008/09, and 2009/10 are shown in Figure 20.

Fig. 20 - Screenshot from Google-Analytics showing the visits per day (y-axis) during 3 winter semesters (x-axis):
Dashed lines depict the time points of examinations for single subjects and the grey boxes show the courses involving pathology: Musculoskeletal and cardiovascular system are taught in the 3rd semester, while gastrointestinal system and genitourinary system are part of the 5th semester. Two to three weeks before examination, traffic increases strongly resulting in a sharp peak of the curve with a maximum of approx. 400 visits per day in WS 2007/08 and 2009/10 and approx. 300 visits per day in WS 2008/09. Note the different graduation of the y-axis. The pattern of visit fingerprint reappears in very similar manner in all three years.
Single subject exams at the end of the organ system courses are marked with dashed lines and a timeline shows the respective courses in grey boxes. In the periods of examination of single subjects during the terms, the profiles of the visits were very sharp in each year. Two to three weeks previous to the examination, traffic rapidly increased resulting in a sharp peak of the server traffic curve with a maximum of approximately 400 visits per day in the winter semesters 2007/08 and 2009/10. In the WS 2008/09 the maximum peak was slightly lower with approximately 300 visits per day. Immediately after examination, a sudden decrease of the visits was observed. The pattern itself was very similar in all three years.

![Graph showing visits per day](image)

Fig. 21 - Screenshots from Google-Analytics showing the visits per day (y-axis) of the summer semesters 2008 and 2009 (x-axis):
Grey arrows show the beginning of the lecture-free period which corresponds to the learning period for the objective structured practical exam (OSPE) in september. Black arrows depict the date of the medical basis examination. The curve shows a more constant pattern of visits distributed over 2 month resulting in a plateau-like visit fingerprint. The smaller peak on the left side of both curves matches the course respiratory system, which is the only one included in the blended learning platform in the summer semester. According to the curricula, the number of visits between end of april and begin of the lecture-free period in July is strongly reduced.

During the preparation of the medical basis examination after the 3rd year the visits were more constant over a longer period of time, building a plateau-like profile. Figure 20 depicts the recording of visits per day between april and
september of the summer term of the years 2008 and 2009. The pattern of visits observed between july and september is less sharp as in the semesters and has no sharp peaks. This curve corresponds to the 2-month long learning period previous to the medical basis examination in september. In the middle of summer term 2008 the average frequency of visits was 23 per day, representing a basic activity of the users. During the learning period in 2008 the average frequency increased to 67 visits per day. In 2009 the beginning of the learning period is marked by an rapid rise in visits to a plateau of averagely 100 visits per day and an abrupt decrease at the date of examination. At the end of the learning period in 2009, a slight increase of visits towards the date of the examination was recorded (Fig. 21).

4.2.2.2. Technical equipment: Hard- and software used by visitors
The changes in technical equipment of the visitors are resumed in figure 22. In each semester the average proportions were calculated for the different hard or software types; i.e. operating system (OS), browser, speed of Internet connection and screen formats of the computer. All relative figures refer to the absolute visits per term given in table 3. Percentages missing up to 100% represent a rest of rarely used hard- or software.

The distribution of operating systems among the visitors was similar in WS 2007/08, SS 2008 and WS 2008/09 with Microsoft Windows making up a share of 88-90% (Fig. 22A). Second most used operating system is Mac OS (Apple Inc.). In summer semester 2009 an abrupt increase in Mac OS-users to 20% from 7-9% in winter semester 2008/09 was observed. The most frequently used browser is Firefox (49-57% of the users, Fig. 22B). The share of Microsoft Internet Explorer is decreasing over the years from 41% in winter semester 2007/08 to 18% in summer semester 2009, corresponding to the increase of the Safari browser rising from 3-6% (WS 2007/08 and 2008/09) to 17% (SS 2009). The increase of the Apple-OS in summer semester 2009 corresponds with the increase of the use of the Safari browser, also from Apple Inc.

As shown in figure 22C, about two thirds of the users are known to have access to a high speed Internet connection. These are used either at home through DSL or through the network of the RWTH Aachen University. Only 18-22% of the visitors use a slow dialup connection.
The screen formats of the computers used by visitors changed strongly between the years 2007 and 2009 (Fig. 22D). Visitors using screens with the format 4:3 decreased steadily from a proportion of 45% in WS 2007/08 to 19% in SS 2009. The share of the generally less used format 5:4 also fell from 14% to 8% in the same time period. Accordingly, the use of computers with wide-screens (e.g. 16:10 or more) among the visitors increased strongly from 39% in the WS 2007/08 to a share of 72% in SS 2009.

Fig. 22 - Bar charts representing the dynamic changes in hardware between 2007 and 09: The majority of operating systems (A) is windows, though this fraction is decreasing and the Mac OS accounts for a rising percentage. The most used browser (B) is Firefox. According to the augmentation of Mac-users, the percentage of visits with safari browser increases as well. This is accompanied by a decrease of the users with MS Internet Explorer. The connection speed (C) was relatively constant with about 2/3 of the visitors using high speed connections either at home (DSL) or via the university network. Only 18-22% of the visitors used slow connections (dialup). The screen formats (D) changed strongly with time. At present the vast majority uses computers with wide screens (72%), suggesting that students have relatively modern hardware.
4.2.2.3. Geographical location and visitor loyalty

The geographical distribution of the visitors to the web-based learning platform over the whole analysis period (October 2007 to September 2009) is visualized in figure 23.

The world map (Fig. 23A) shows that 95.6% of the visitors are located in Germany. Most of the users are recorded around Aachen (Fig. 23B, arrow). Since the content is network-independent, students were able to learn from other places than Aachen, e.g. at the house of their parents. This issue is one of the reasons for the spread of the geographical locations.

The number of times a visitor has returned to the website between October 2007 and September 2009 (so called visitor loyalty) is shown in figure 23B. About a third of the visits are recorded as a single visit (30.97%). However, visitors returning between 9 and more than 200 times also account for a third of all visits (32.57%). The rest (36.46%) is recorded as second to 8th visit of a returning visitor.

![Geographical distribution and visitor loyalty](https://via.placeholder.com/150)

**Fig. 23 - Screenshot from Google-Analytics showing two examples of recorded data regarding the geographic location (A+B) and the visitor loyalty (C):**

The data refer exemplarily to the time period between October 2007 and September 2009 with a total number of 33,871 visits to the website.

Geographical distribution: 95.6% visits are located in Germany (A). Most of the users are located around Aachen (B, arrow).

Loyalty of visitors (C): 30.97% of visits were recorded as first access to the website. 32.57% were the 9th to 200th visit, whereas 36.46% were the second to 8th access.
5. Discussion

5.1. Blended learning in pathology at the RWTH Aachen University

In the everyday life of students the Internet and its applications play an important role. In medical education, Internet-based learning content has expanded strongly over years. Today it is a basis of medical teaching in many faculties. Specific pathology related web sites comprise databases with macroscopical or histological pictures and increasingly collections of virtual histological slides (Böhm 2008, Glatz-Krieger et al. 2003a). Podcasting is also used to explain pathological topics, though mostly they are audio podcasts or podcasts consisting of pictures with audio comments (Woosley 2006, Hulman). New computer technologies allow methods like the virtual microscopy or video podcasting. These new internet options can still be used more refined. For example the use of annotations enhances virtual slides considerably and the use of dynamic videos in podcasts renders the presentation of pathological findings much more realistic and memorable.

At the institute for pathology of the RWTH Aachen University a blended learning platform has been established and continuously developed and complemented since 2006 by Dr. Alberto Pérez-Bouza. It includes a large collection of virtual slides which is continuously growing and has been improved with written annotations to highlight histological findings. The video-podcast „PathoCast“ was introduced in a second step. Video episodes cover meanwhile many of the curricular organ systems of the „Modellstudiengang.“ The web site has no restricted access or password protected areas, which allows a quick and easy navigation for students not only of the RWTH Aachen University. This open access allows other potential students to meet the learning environment before choosing a university.

As Wong et al. (2010) points out, the success and acceptance of a web-based learning offer has to be evaluated with respect to the expected target group. The learning platform (www.vm.rwth-aachen.de) is conceived as blended-learning offer which matches the curriculum of the Aachener Modellstudiengang Medizin. The primarily expected target group are the students from the 3rd to 6th semester, who pass through the courses of different organ systems and
have to reproduce this knowledge in the medical basis examination after the 6th semester.

5.2. **Students of the RWTH as main users of the web-based and curriculum-related content**

It cannot be directly proved in each single case, that the registered user traffic is caused by medical students from RWTH Aachen. Nevertheless, many indirect hints show in summary that the great majority of visits to the web site come from students in the Aachener Modellstudiengang:

First, there is a strong correlation of the visits per day with the dates of the exams, which is found every year in very similar manner.

Second, there is no major increase of the overall visits after three years, which supports the idea that the content is not regularly used by a large group of students from other universities. The number of visits remained relatively constant and kept the proportion to the number of students during the periods of time analyzed in this study (see table 3).

Third, in the time between the courses and learning periods, when little use is expected from students of the RWTH, the basic traffic to the web site also remained very low.

Fourth, the geographical location of students is an additional indicator. As Google-Analytics show, nearly all visitors were located in Germany with the majority around Aachen and in 20-33% of cases the web site was retrieved directly from the network of the RWTH (mops or eduroam).

5.3. **Publishing video-based teaching content through podcasting**

The concept of the podcast „PathoCast“ is not as close to the curriculum of the Modellstudiengang as the design for the web site. The episodes cover generally topics that students usually find to be difficult to understand. The videos are also published without restrictions through the video platform blip.tv with a RSS-Feed. It is in the nature of the interactive web 2.0, that the podcast which was originally published on blip.tv and iTunes is cross linked and copied by other users and can be thus found today on several other web sites (e.g. podcast.de; mefeedia.com; channels.com, truveo.com; casttv.com). This spreading of the content in the web can be followed by looking at the view statistics: The absolute number of daily views in each winter or summer semester is increasing
exponentially from 16.144 during WS 07/08 to 60.106 during WS 09/10 (see table 3) and correspondingly the baseline of daily views between the courses or learning periods is growing stronger. Overall since the introduction of the podcast until september 2010 the 35 videos had together 281.000 views. On the one hand, this may be partly explained by students from older semesters who still subscribe to the podcast and also receive new episodes, which are uploaded. On the other hand, it can also reflect that other people, possibly students from other universities, are watching the podcast videos as well. However, the increasing activity in daily view counts during the courses in the winter semester with the decrease after the examination shows that the students, who currently pass the organ system courses also watch the videos frequently. When the analysis is focused on the daily views of cross-linked videos from the web site www.vm.rwth-aachen.de (see Fig. 18) a much more clear pattern is depicted, which highly correlates to the web statistics of Google Analytics.

5.4. Usage behavior on the web-based learning platform

5.4.1. Profiles of server traffic depending on the examination

The daily view statistics of the web site reveal two different usage patterns, which also correlate to two different learning strategies: one in the courses during the semester and the other during revision prior to the general exam. During the semesters the high activity on the web site is registered as sharp peaks towards the end of each course, which suggest a short and intensive learning phase immediately before the examination. This corresponds to the general experience of students, as the curriculum of the organ system courses is extensive and the time for revision during the course itself is short. The surveys in the „Modellstudiengang“ concerning the course cardiovascular system confirm the intensive use before examination, as the students indicated in 70% that the podcast and in 53% that the virtual microscope had contributed to an effective revision previous to the exam. The preparation of the general exam after the 6th semester usually takes 2 months. In this period of time, a plateau-like pattern of the server traffic with no relevant peaks was observed, which suggests the use of the didactic material in a more constant manner by a concrete group of students learning for this exam.
Moreover, there is no relevant increase of the activity for last-minute-revision at the end of the 2 months. The overall server traffic in the learning period for the general exam has increased with time as the blended-learning platform has grown since 2006. This can be interpreted as a positive sign since students use the platform more intensively the more content is added. The blended learning platform has thus been established as integral part of pathology teaching in many courses of the „Modellstudiengang“ like cardiovascular, gastrointestinal, musculoskeletal or and genitourinary system. Furthermore students have also integrated the virtual microscope and the videos into their revision schedule for the general examination.

5.4.2. Frequency of use of the virtual microscope
In the Regelstudiengang, the questionnaire asked for concrete usage frequencies and lengths (Q1) and the majority of students indicated a very frequent (daily to twice per week: 75%) and rather long use (30 min to >60min. per session: 70%) of the virtual microscope. In Q2 for the Modellstudiengang students rated the frequency on a scale and thus subjectively in relation to their other activities. Overall the median of use frequency was 4 out of 7 for the virtual microscope. These differences between the Regel- and the Modellstudiengang are caused by the fact that students in the Regelstudiengang had a practical course in general and organ histopathology as important part of the curriculum. In the period previous to the examinations, this course was one of the main subjects while in the Modellstudiengang the histopathology is integrated in the general concept of the organ-orientated and multidisciplinary education. Students in the Modellstudiengang do not concentrate efforts on histopathology, which is rather a complement of the lessons.

The parameter „visitor loyalty“ in Google Analytics (Fig. 23) gives important information about the use of the learning platform. It shows that among users are very faithful ones. A third of the visits (32.8%) was already the 9th to 200th time a user returned to the web site. This parameter separate clearly the sporadic clicks from the systematic visits e.g. during the preparation of an exam. The loyalty can only be recorded if the cookies set on the computer on the first visit are not deleted. Thus it cannot be excluded that some visitors used
different computers or have deleted the cookies after every visit, being recorded as a new instead of a returning visitor.

The data of the daily visit and view counts with Google Analytics and blip.tv respectively do not allow conclusions on the absolute usage frequency or visit length of the students but they do clearly show a relatively lower activity in WS 2008/09 which corresponds to the results of the questionnaire in the second evaluated student group.

5.4.3. Statistical differences between semesters: A matter of communication?

In the Modellstudiengang most students from the first and the third evaluated year used the virtual microscope and especially the podcasts frequently, while in the second year of evaluation students were less frequent users. This dip to lower points in WS 2008/09 is also seen for other parameters concerning the podcast, like contribution to effective revision, fun and the overall rating. In the WS 2007/08, students had an introductory class to the on that time new systems (virtual microscopy and video podcasting). In the WS 2008/09, organizers supposed that the students already knew the system and that no extra explanations were needed. At the end of the semester it becomes clear that this assumption was wrong: Many students did not combine properly the Internet-based content with the content of the lessons. This issue was found in the statistical analysis of the surveys and also in the commentaries of the internal evaluation system of the faculty (EVALUNA).

In consequence, in the WS 2009/10 the different components of the learning platform and the possibilities of access were again presented in detail in an extra lesson of 45 minutes just previous to the begin of the main lessons. As result of this „better communication“ the usage frequency rose to a similar level as in WS 2007/08 and the results of the surveys reached the same levels as in the first year of use.

These results also suggest that not all students are automatically familiar with the use of web 2.0 tools, e.g. podcasts, even though this generation is in general conversant with computers and the internet. To enable as many students as possible to benefit from the learning offers it is of crucial importance to explain the technical aspects and the general concept of the project in each year.
5.5. Monitoring changes in software and hardware of users for development towards the right direction

The technical possibilities, which were assessed in the questionnaire 1 for the „Regelstudiengang“, are in general sufficient to access the content without barriers. Over 80% had access to high-speed Internet connections, a prerequisite for the optimal use of the virtual microscopy (Glatz-Krieger et al. 2006a). The surveys in the „Modellstudiengang“ (Q2) revealed, that the number of students who could also profit from the extra possibilities provided by portable players has increased to nearly a fifth in WS 2009/10. Though for the learning benefit, the content is more crucial than the mobility of replay.

The analysis of the hard- and software of the users of the web-based learning platform show that a tendency towards the browser Firefox has developed in the past three years. Firefox is now the most frequently used browser and the trend in screen formats points to wide screens (at present 72%). These facts together with the use of higher screen resolutions (not shown in the figures) suggest that students keep up to date with modern hardware.

Windows is the most common operative system. However, in the last 12 months there is an important increase from 9% to 20% of users which have a Mac-OS. This trend correlates to the expansion of mobile devices like the iPod or iPad in the last years. The use of a more or less universal browser and an overall compatible operative system is important to avoid barriers when accessing complex systems like the virtual microscope.

5.6. Acceptance of the learning platform by students

5.6.1. Virtual microscopy and annotations highly appreciated

The concept of supporting the conventional histopathology courses with a blended-learning histology-platform was broadly accepted and positively evaluated. In the „Regelstudiengang“ the possibility of visualizing whole histological slides at any time and from places remote to the university (mainly at home) was highly appreciated since the practical course was essential part of the semester and students had more than 30 cases to study. Students shared the opinion of other groups concerning the benefits of whole digital slides over conventional photomicrographs (Dee et al. 2007; Harris et al. 2001; Heidger et al. 2002; Kumar et al. 2006).
Students both in the „Regelstudiengang“ and in the „Modellstudiengang“ greatly appreciated the possibility of obtaining a written explanation of highlighted areas of the virtual slide (annotations). This is an important aspect as it greatly facilitates theory comprehension and practical examination of the slides. The need for annotations was also expressed by students of other universities which offer virtual histology courses (i.e. University of Iowa (Harris et al. 2001, Dee et al. 2007), University of Basel (Glatz-Krieger et al. 2006a).

In the „Modellstudiengang“ many students would welcome a self assessment option for the virtual microscope and some supported the idea of unlabeled slides for self diagnosis enthusiastically in the comments.

5.6.2. Podcasting of teaching videos as support to regular courses

The attitude of the students in the „Modellstudiengang“ towards the podcast „PathoCast“ was equally positive. Videos were appreciated for their short and compact illustration of relevant findings, their integration of clinical into pathological topics including the histopathology and also their ability to enhance the learning fun. Furthermore students prized the videos as effective tools for recapitulation before examinations. Generally podcasts also attract attention in other medical specialties and show a great expansion through iTunes (see Whitehead et al. 2007 and Boulos et al. 2006).

Videos are thought to be a support of the regular courses and focus in complex issues. Because videos are carefully orientated to the curricula, and in the way how videos are built, students with no previous knowledge of the theory can follow the explanations without problems. Moreover, the content of the videos offer a new sight of illness, since organs are shown in detail and while being cut and processed for histology, thus helping understanding histological findings. Within the videos complexity increases („from anatomy to the clinic“), so the they also become interesting for students of later semesters. Videos are designed to be the „key to the books“ and not to substitute them. The pure reproduction of the text from books does not increase the value of the method.

The university is a centrum of knowledge where students get information, have contact to experienced teachers, discuss with them and with each other and learn practical skills. Moreover, how to search for information in classical books or in the Internet is also a crucial part of medical education, thus the substitution of classical contents and university teaching should never be reduced to videos.
5.6.3. Differences between single episodes of the podcast

The comparison of the traffic on single episodes in a particular time window like the revision of the general exam (Fig. 19) shows which videos were watched in a range oscillating between 50% above or 50% below the average. The differences might result from different levels of complexity of the topics of amount of clinical references. Further, diseases like „stenosis of the aortic valve“, „lung edema“, „thrombosis and embolism“ or „gastritis“ are very common and clinical of great relevance, reflecting the higher ranking in the frequency of visits. No videos were watched less than a standard deviation, suggesting that all videos offered a level of information high enough to be used at least one time.

The division in chapters was introduced because students found some videos too long (EVALUNA 2007). Chapters have tags or keywords which correlate with the curricula. These tags allow users to „navigate“ through a video and precisely look for issues which need revision without hearing the whole content. Chapters allow creating larger videos without reducing the attractiveness.

The relatively low chapter use at the beginning might have occurred, because some students felt that they do not need them, but also because they might not know how to use them. Thus the function was made clear, when introducing the podcasts at the beginning of the course, and the percentages have risen.

5.7. Perspectives

The presented data have been recorded over three years. An uninterrupted data sampling over several generations of students will depict interesting trends in learning behavior and technical requirements.

The usage behavior of the three different years of students repeats itself in very similar manner which indicates a similar spontaneous learning strategy. Continuing analysis might reveal a change in this pattern and thus a different learning strategy in a new group of students.

Furthermore it will be interesting to see, weather the dip in usage frequency from the WS 2008/09 will reappear before the medical basis examination of the same group of students in autumn 2010. This would show if the students became more familiar with the blended learning platform during the 4th to 6th semester or not.
For an effective improvement of the project it is helpful to discern between features that appeal generally to the students and those that are appreciated only by certain groups. Consequently the expansion of broadly supported features, for example the annotations on the virtual slides, will have a bigger impact on students satisfaction with the learning platform than for example the creation of a self assessment option.

The continuing development in hard- and software considerably affects the design of internet sites and didactic material such as videos. For example the change in screen formats raises the question, whether the videos should be adjusted to a wide format in order to make the most of the full screen replay.

In this work the analysis of the server traffic focuses on the entry web page of the learning platform. However, Google-Analytics can be installed to every single web page, so that it is possible to analyze them separately. With the analysis of the visits to the different learning units a usage profile of a group of students can be given. Furthermore it is possible to follow the pathway chosen by students on the web site, which may help to enhance the usability. Length and frequency of students visits to the different web pages inside the platform may give indirect information about e.g. the difficulty of understanding the content.

In the present surveys 72% of students in the „Modellstudiengang“ have returned the questionnaires and a higher response rate is desirable to reduce a possible non-response bias.

This work focuses on subjective impressions and usage behavior of the students, but it does not factor the outcome of this different learning approach. Further studies should verify, weather students who have used the blended learning platform also score better at the examinations - both the exams during the semester and the medical basis examination.

This internet-based teaching method is highly accepted and frequently used. In the „Modellstudiengang“ most students (65%) see web-based methods as supplement to the present text books while a fifth of the students agrees, that this kind of teaching could even replace classical medical books. In the next years will be of strong interest to see how this opinion develops. With the introduction of new devices like the ebooks or the iPad, specially in combination with high-speed Internet connections, new perspectives arise. Books consisting
of 100% digital material (text, videos, pictures etc) will probably have now the opportunity to expand.
6. References

**Web sites, last accessed 30.08.2010:**

27. http://www.aperio.com
29. http://www.path.uiowa.edu/virtualslidebox (University of Iowa)
30. http://www.pathol.uzh.ch/histologiekurs (University of Zürich)

**Podcasts, last accessed 30.08.2010:**

34. Baba HA „Pathcast“, RSS-Feed: http://www.pathcast.de/?q=audio/feed
35. Fournet JC „Pathologie générale“, RSS-Feed:
36. Hulman G „Pathology mini tutorials“, RSS-Feed:
   http://itunes.apple.com/de/podcast/pathology-mini-tutorials/id343794004
Publications


Acknowledgements

The blended learning platform and the project „PathoCast“ was financially supported by the Medical Faculty of the RWTH Aachen University.

I would like to thank Professor Ruth Knüchel-Clarke for the supervision of this work and also for her mentoring, her useful comments and the critical revision of the manuscript.
Sandra Sudmann from the Deanery of the Medical Faculty for her help during the development of the learning project.
Professor Siegfried Gauggel from the Institute of Medical Psychology and Sociology for his constructive advice during the preparation of the work.
Fabian Bärtling, Andreas Kneist, Lilian Masuhr and Roman von Stillfried for their work and ideas in the augmentation of the project and for creating the videos.
Isabel Rieck additionally for her help with transferring the data from surveys.
Ralf Krimpelbein from the IT Department for the technical support.
The students of the Medical Faculty of the RWTH Aachen for their participation in the surveys and for their constructive criticism.
And a very big thank you to Dr. Alberto Pérez-Bouza for the development of the project and for guidance through this work. He introduced me to the pleasure of creating e-learning material, encouraged me or sometimes slowed me down and overall never lost track of the aim of the work. I thank him for his counsel and above all his contagious enthusiasm.
I would also like to thank my parents, Christine and Franz for their continuous support and Magdalene Hauri and Hansruedi Hübscher for their constructive criticism.
Erklärung zur Datenaufbewahrung

Hiermit erkläre ich, dass die dieser Dissertation zu Grunde liegenden Originaldaten im Institut für Pathologie des Universitätsklinikums Aachen hinterlegt sind.
Lebenslauf

Persönliche Daten:
Name: Magdalene Olga Merk
Geburtsort: Aachen

Ausbildung:
1990 – 1994 Gemeinschaftsgrundschule Laurensberg
1994 – 2003 Einhard - Gymnasium, Aachen
2003 – 2010 Studium der Humanmedizin, RWTH Aachen

Berufliche Tätigkeit:
seit 09/2010 Assistenzärztin in der Klinik für Allgemein-, Viszeral- und Kinderchirurgie, Klinikum Pforzheim