Practical Testing in Oral Exams

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Introduction

Oral exams in biomedical education close the gap between written tests and examinations during practical courses. The latter are very close to real applications but lack from being complex and time-consuming. Introducing electronic assessments in oral exams is suitable to overcome these disadvantages. And, still more important, using additional modalities in oral exams may upvalue oral assessments.

Methods

Students of biomedical engineering who must pass an oral exam have been divided into a treatment and a control group. During a standard oral exam with varying content, both groups were asked a pre-defined set of questions that address learning aims in the area of electric biosignals (ECG, EMG, EEG). While the control group gave oral responses, the treatment group was asked to complete these exercises by working with an ECG monitor or with a tablet running a self-programmed virtual diagnostics app.

Results

Although being in a stressful situation, students are able to operate the hardware and to monitor their own biosignals. This renders the oral exam more valid, since it becomes possible to test not only those practical skills that have been taught but also whether there is a transfer of learning from theory across practice to understanding, according to Bloom’s taxonomy.

Conclusion

The use of tablets will be extended, since this provides a good compromise between the necessary presentation of real biosignals (graphs, audio, video) and the necessary workload for the lecturer’s preparation of the exams. To most of the tested students, the integration of actual media seems to be very motivating, even in an oral exam’s stressful situation.
Educational Goals, Competencies, Performance — How to Describe the Learning Outcomes of Study Programmes in Biomedical Engineering?

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Introduction

The Education and Training Committee of the German Society for Biomedical Engineering within VDE aims at introducing a Quality Seal for study programmes in Biomedical Engineering. This makes it necessary to define requirements for the curricula of such study programmes. In addition to the definition of the extent of the different subject areas, the Bologna process requires to define learning outcomes. A great variety of approaches and models are now available for describing and classifying learning outcomes, including different ‘taxonomies’.

Methods

This project outlines a number of different approaches and provides an analysis of various options available for defining the framework (subject range and learning outcomes) of study programmes in Biomedical Engineering.

Results

It is hoped that this project will give rise to a discussion (followed by a decision) as to which method to choose to describe Learning Outcomes in Biomedical Engineering.

Conclusion

The descriptions of these Learning Outcomes will be part of the requirements to be met for the award of the Quality Seal for study programmes in Biomedical Engineering.
Criteria for Selection of Web-based Video Technologies

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Introduction

There are several file formats, compression methods and technologies to deliver video data on the web. Thereby, videos have been established on the web in increasingly better quality during the last years. However, technically videos are often still a foreign body on the web.

To embed videos in our learning management system, there comes a variety of technologies into consideration. This raises the question: What is the most useful technical solution for our user group and how it can be determined?

Methods

The video technologies were classified in: Client-side technologies, server-side technologies, data formats and compression methods. Furthermore, browser access to learning modules was statistically analysed and various criteria were defined to evaluate the technologies.

Results

The analysis of various technologies shows that it is necessary to weigh them against each other. Therefore the following criteria have been created to distinguish different requirements: The browser support, the video quality, the data economy (coding efficiency, streaming) and the future orientation of the technology. These criteria must be weighted. This could either lead to a full support for all used browsers or to a restriction on modern or most used browsers. The best solution for all criteria does not exist.

To consider all criteria, more than one solution has to be established. The video server should take over the selection of an appropriate technology and the management of the videos including the generation of various qualities and formats.

We developed a flexible video server with a constant interface for embedding videos into web pages.

Conclusion

Besides the choice of a video format and a compression method there are different ways to deliver videos. On the one hand browser manufacturers have no uniform strategy for video support, on the other hand the progress of video technology continues. Therefore a video server should take care of it.
Demands on a continuing education online-study program for physicians

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Abstract
Physicians have an intense and irregular workday life. Thus, they need to use their time for continuing education in a most efficient way. This presents a major challenge to suppliers of continuing study programs. As such a supplier of an online master program we could gain experience in this field for about almost four years. By evaluating the master program, we found certain requirements which allow working physicians to study efficiently and successfully.

1 Introduction
Although our online master program Physico-Technical Medicine (PTM) is also open for engineers working in the biomedical field and graduates of other life-sciences we primarily address working physicians who want to acquire competences in the fields of biomedical engineering and medical physics [1]. Thereby we attach great importance to the special needs of our participants [2,3]. In order to answer the question if we satisfy our students’ requirements, we investigated which general conditions are most important for the working physician regarding qualifying continuing education.

1.1 The Master Program
The online master program Physico-Technical Medicine is a continuing study program. The blended learning concept allows flexible learning: About 80 per cent of the study program can be completed online, around 20 per cent of the program are attendance time.
Within the first two semesters, there are basics in physics, measurement techniques, biosignal processing, radiophysics, informatics, and programming taught (Image 1). In the third and fourth semester students can choose two out of four advanced modules for specialization which are “Technology in Intensive Care Medicine and Anaesthesiology”, “Medical Imaging”, “Technology in Surgery”, and “Medical Informatics”. Additionally there is the module “Management Competences” providing scientific and leadership qualifications such as medical business administration and scientific writing. After completing the master thesis during the fifth semester, students graduate with the degree “Master of Science”.

Students are supported by professionally trained online tutors. During the whole study time there are interdisciplinary tutors available who introduce the methods of e-learning in the first place and help students to organize their learning activities. They are furthermore contact persons providing support for any technical and personal problems around the study program.
In the first and second semester specialized tutors attend the students also in each subject additionally to the lecturer. They explain certain topics on demand and answer questions very quickly.
Besides this intense learning support, general advice about the study program and technical support are provided (Image 2).

1.2 The Target Group
The main target group of the online master program PTM are physicians who have to deal with an increasing number of technical instruments during their workday life. These are for example anesthesiologists, surgeons, cardiologists, internal specialists, but also other specialists.
In general, physicians have a very intense workday life: They shoulder a lot of responsibility, workdays are intellectually demanding, they have to deal with shifts and they...
are meeting high demands. Therefore, the concept of a study program for this target group has to be adjusted to their special situation.

2 Methods

The general conditions of our continuing education program (PTM) were examined on the basis of evaluation questionnaires which are distributed at the end of every semester. Students were asked for their opinion about the following items: course contents, learning materials, time management, supervision, and overall impression. The students could score their agreement on a scale ranging from 1 (fully disagree) to 5 (fully agree). Additionally the students could give free comments about the course. Finally they were asked about their weekly workload and if they felt the workload appropriate.

In addition, students were asked in interviews about their demands during their studies and they could also give anonymous feedback on feedback-cards.

3 Results

We found five main requirements which enable working physicians to study more efficiently (Image 3):

Flexibility: Students appreciated flexibility regarding time and environment of their learning activities. This flexibility enables the students to use even small time frames or traveling times for learning. Students can choose their preferred time and place for their learning activities.

Security in planning: Students have to organize their time frames for learning besides their daily work, their family life, and possibly their academic career. Especially phases of attendance should be planned and communicated as early as possible.

Transparency of structure: Participants ask for transparency in terms of the expected workload and expenditure of time to plan their studies and to get focused.

Relation to previous knowledge: Learning success is supported by relating new contents to previous knowledge from the student’s first medical degree. Mainly clinical examples illustrate abstract topics, which also helps students to recognize the relevance of the content.

Individual support: Students need contact persons in terms of learning organization, technical support, and for questions regarding the course material.

4 Conclusion

We could show that an extra-occupational continuing study program for physicians should be adjusted to their special situation and therefore has to comply with particular requirements. As such we could identify five main requirements of a study course for physicians: Flexibility, Security in planning, Transparency of structure, Relation to previous knowledge and Individual support.

The online master program Physico-Technical Medicine is conducted as a blended learning concept, that offers students the required flexibility to organize their learning activities independently. To ensure security in planning, the curriculum and especially phases of attendance are planned and communicated one year in advance. The structure of the curriculum is communicated via different media: as print format, in a digital calendar, and in the forum of the learning platform. Lecturers are aware of the student’s medical background and refer to it in their lectures, seminars, or practical trainings. Individual support is provided during the whole study time (cf. section 1.1 “The Master Program”).

We continually evaluate the fitting of these requirements and adjust the study program if necessary.

5 References

The deployment of interactive presentation media in medical physics and biophysics: a novel approach to improve quality and dynamics of plenary lectures.

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Abstract

Interactive whiteboard (IWB) technology has infiltrated education at a primary and secondary level during the last decade. Higher education at a university level was less or not affected by this development in education. The benefit of IWB specifically when teaching science is seen critically and ambivalent. We used interactive pen controlled mobile devices combined with a novel format of presentation handouts within a peer reviewed lecture project of physics in medicine. The goal of the project was a) to align presentation velocity of the teacher with the velocity of reading, writing and making annotations in the audience, b) to make presentation more flexible and dynamic allowing spontaneous changes and adds and c) to evaluate how this effort is seen by the peer and by the students. The peer group consisted of 9 academic members from different disciplines and of 13 student members. The peer group as well as 131 students from the audience evaluated a lecture serie of twelve one-hour lectures given in electricity and bioelectricity. A feedback form of 25 questions was filled out from the peers as well as from the students. The use of the interactive tablet combined with adequate handouts and with an enhanced communication between lecturer and the audience was judged most positive by all participants. The highest scores were obtained with the topics course material, communication, technology. The positive effect was stronger in experienced students and peers, weaker in students with low precourse knowledge, possibly indicating that the combination of knowledge transfer and technology was to demanding. With respect to gender, the results of the que-tionnaire showed a significant improvement of knowledge for both sexes, whereas female students started at a lower level of preknowledge. No gender gap was observed for the other questions.

1 Introduction

Nowadays at least a large part of learning material can be accessed by students and teachers from the University inhouse learning management system (LMS). For lectures usually a list information of the learning goals, recommended textbooks and handouts of a powerpoint presentation in PDF format is available. Beamer technology combined with personal computers for presentation can be found in every lecture hall. The lectures prepared with presentation programs can be refined by means of embedded multimedia contents. Computer programs of virtual experiments available in the worldwide web like PhysLets [1], custom designed video animation and computer simulation of complex dynamic processes like the cardiac excitation spread can be built in a lecture presentation. The disadvantage of such a presentation is its static sequence of contents, which impedes any surprising pathway due to i.e. students questions or comments during the lecture. Unexpected contents and the corresponding explanation have to be treated by changing the medium, drawing on the blackboard and switching off the presentation. The required explanations, comments, notes and drawings can only be made on a medium different from the PC-screen and not directly on the current graphic sheet presented and project-ed at the front wall of the lecture hall.

From 2000 on, a new media technology called interactive whiteboard (IWB) was introduced widely at schools. IWBs allowed to write and draw with an electronic pen on a huge screen of presentation and to transfer the result digitally to the LMS. Years later overlay technology was added to allow writing and drawing not only on empty screens but also on pictures and sheets of the presentation itself. IWB widely spreaded in primary and secondary level schools [2], but less at medical schools and universities [3]. Their benefit and efficacy in the learning process was topic of surveys and studies with quite controversial results, highly dependent on the level of education and the field of matter [2,3,4]. The widespread use of electronic notebooks and specifically of electronic tablets by students has introduced a substantial amount of additional distraction and diversion during the lecture. The classical former “chatting with neighbours” was replaced by electronic communication and exchange of data not related to the topic of lecture via web (interesting images, video films, news and messages). Reading and answering e-mails and SMS during the lecture often impedes students from being focused on the topics of the lecture. On the other hand, specifically interactive tablets provided with pen technology could be used from students as a novel approach for creating personalized notes of a lecture based on handouts delivered electronically.
The work presented here describes the deployment of very advanced and recent interactive large scale (22-24") tablet technology to enrich electronic presentations with an overlay-technique of hand writing and drawing by means of an electronic pen. The new presentation technique was accomplished by a novel format on handouts optimized for annotations made by students at paper or at tablets. The impact of this new format on student attention and learning behaviour during the lecture was analysed by means of questionnaires.

2 Methods

New extra-large interactive pen displays (IPD) (DTK-2241, Wacom, Japan) provided with state of the art interactive pen-technology was placed on a lectern and connected with a notebook via USB- and DVI-connector. Driver software of the display, as well as a specific pen control and a free whiteboard software (Open-Sankoré, Lausanne Switzerland) was installed to run the pen-drawing program and its integration with standard programs like PowerPoint (Microsoft, Redmont, USA) and Corel-Draw (Corel Corp., Ottawa, Canada). The DVI output of the IPD was connected to input of the beamer unit. By means of the interactive pen, control of all PC-programs and switching from the desktop screen to any application program or to the special whiteboard or blackboard simulation program of Open-Sankoré could be executed without turning off the screen projection and changing abruptly the medium. The teacher does not need to move to the blackboard turning the back towards the audience. Hence uninterrupted eye contact of the lecturer with the audience becomes possible to enhance the general attention.

A textbook for students was designed with semi-finished handouts of Powerpoint presentations to be completed during the lecture by the lecturer at the IPD as well as by students in the text book with hand drawings and writing notes by hand. Since the textbook is deliverered via the LMS as PDF-file the comments and notes could also be made on electronic tablets equipped with pen technology. In this way every student can get an individualized copy of the presentation, and the speed of presentation becomes aligned to the writing speed of students by the simultaneous writing procedure of the teacher on the IPD.

Within a project "PRL, the peer reviewed lecture", a group of 13 beginner and advanced students and of 9 academic colleagues of the same field as well as of other disciplines joined a sequence of 12 hours of lecture in "Electricity & Bioelectricity". A questionnaire was designed to explore the view of students as well as of colleagues in terms of many didactic aspects. Among these the adoption process of this new technology and teaching format was also matter of discussion. The peers filled out the questionnaire for every session, the non-peer students (131) after the whole sequence of 12 lectures. Among of 25 questions concerning data of students, orginsational, content and didactic matters, some of the questions were addressed to the use of this technology and to the format of lecture notes. In detail these questions were to rate in scaling from 0 to 10 (0 is weak, 10 is excellent). Specific attention we paid on the following topics:

- the pre-course knowledge for this lecture
- the communication with the lecturer
- the quality of multimedia contents
- the quality of multimedia technology
- learning material (handouts)
From the questionnaires we got additional information about sex, age and current semester of the students. Information of the academic peers was used to judge the lecture from the perspective of academic teachers. Some of them were close to Physics (Biophysics, Mathematics, Chemistry, Biochemistry) others far (education science, histology, etc.).

3 Results

<table>
<thead>
<tr>
<th>Topic</th>
<th>peers mean±sd</th>
<th>students mean±sd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge transfer</td>
<td>7.7±1.5</td>
<td>7.3±1.7</td>
</tr>
<tr>
<td>previous knowledge</td>
<td>5.6±2.9</td>
<td>5.5±3.0</td>
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<tr>
<td>Knowledge improvement</td>
<td>7.3±2.0</td>
<td>6.0±2.4</td>
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<tr>
<td>red thread</td>
<td>8.1±1.6</td>
<td>7.4±2.2</td>
</tr>
<tr>
<td>Communication</td>
<td>8.4±1.7</td>
<td>8.7±1.5</td>
</tr>
<tr>
<td>course material</td>
<td>8.7±1.4</td>
<td>8.2±1.7</td>
</tr>
<tr>
<td>Handouts</td>
<td>8.5±1.5</td>
<td>7.3±1.8</td>
</tr>
<tr>
<td>Presentation skills</td>
<td>8.6±1.4</td>
<td>8.3±1.6</td>
</tr>
<tr>
<td>Technology</td>
<td>9.1±1.2</td>
<td>8.7±1.4</td>
</tr>
</tbody>
</table>

Table 1. Results of the questionnaire. Number of peers was 21, number of students was 131.

Table 1 show similar results from both peers and students. Peers tended to give higher ratings than students (not significant). With respect to gender, the results of the questionnaires showed a significant improvement of knowledge for both sexes with female students starting at a lower level (p<0.001). No gender gap was observed for the other questions. We compared results with respect to the previous knowledge: significant differences between students and peers were observed for knowledge transfer (p<0.001) and for improvement of knowledge (p<0.001), with the lowest knowledge improvement coming from student with low precourse knowledge. Students with higher basic knowledge also gave higher ratings than those with low precourse knowledge.

4 Conclusions

The use of the interactive pen display technology IPD combined with adequate handouts and with an enhanced communication between lecturer and the audience was judged most positive by all participants. The highest scores were obtained with the topics course material, communication, technology. It cannot be ruled out, that the effect of “new and sexy” technology was part of the positive impression. The positive effect was stronger in experienced students and peers, weaker in students with low precourse knowledge, possibly indicating that the combination of knowledge transfer and technology was too demanding. In an earlier study about the use of virtual experiments with Physlets we found that students with a higher level of previous knowledge had a higher benefit from using interactive simulation tools than those with lower level of knowledge [5, 6]. This is in contrast to the findings presented here. A possible explanation might be, that the topic of this work was related to lecture tools requiring interactivity of the teacher, whereas the Physlets study was focused on student self-study activities with new interactive tools.

We found that female students were starting from a lower self-reported level of knowledge than male students. This might be caused by a gender gap in pre-university education in Physics. This effect we also found analyzing data from admittance procedures. To some extent students did not expect course material which requires completion by personal drawings and annotations. Usually presentations can be accessed as PDF-files from the LMS. For those students using their mobile phone as PDF-reader to follow the lecture, the material provided became useless because of improper screen size and missing ability to add explanatory notes and drawings. This cannot be verified from the questionnaires, but was observed by several peers.

From discussions with the peers and from free comments of students we conclude that learning habits need more time for change and that this change may differ markedly between early adopters, majority and laggards. From the point of view of the lecturer, the new feeling of presenta-
tion, standing at a central point in the hall, getting the flexibility of spontaneous changes in the presentation by adding notes and drawings was seen as a very positive contribution in quality of teaching. We hope that the use of “interactive” handouts available in printed or in electronic format will encourage students over time to accomplish these material to produce their own personal transcript. The encouraging trend to replace lectures by different new teaching formats (i.e. problem based learning PBL) in small groups seems to be confronted with a drawback due to costs. During the next years we will be faced with substantial economical restrictions in education, which will force universities to resolve the problem by reducing expensive teaching formats and looking for relatively cost saving knowledge transfer to large numbers of students. Apart from e-learning solutions the live-presentation in large lecture halls will deployed increasingly in the future. We are convinced that a change of this teaching format towards more personalized interaction like presented here could help to improve teaching and learning quality. The production of presentations useful for interactive annotations is more time consuming than standard presentations; we feel however, that the drawback of the additional effort to produce this type of lecture material is more than compensated by the advantage of improvement of knowledge transfer and its applicability to larger student groups.

5 References

Equipment for RF Ablation – A Challenge for Biomedical Engineering Students

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Introduction

Despite lots of developments in the last years, radiofrequency ablation of rhythm diseases is a safe but still complex procedure that requires special experience and expertise of the physicians and biomedical engineers. Thus, there is a need of special trainings to become familiar with the different equipment and to explain several effects that can be observed during clinical routine.

Methods

The Offenburg University of Applied Sciences offers a biomedical engineering study path specialized in the fields of cardiology, electrophysiology and cardiac electronic implants. It’s Peter Osypka Institute for Pacing and Ablation provides teaching following the slogan “Learning by watching, touching and adjusting”. It conducts lots of trainings for students as well as young physicians interested in electrophysiology and radiofrequency ablation.

Results

In-vitro trainings will be provided using the Osypka HAT 200 and HAT300s, Stockert EPshuttle and SmartAblate system as well as the Boston EPT-1000XP and Maestro 3000 and the Radionics RFG-3E cardiac radio frequency ablation generators. All of them require different handling as well as special accessories like catheter connection cables or boxes and back plates. The participants will be trained in the setup of temperature, power and cut-off impedance dependent on different ablation catheters. Furthermore troubleshooting in hard- and software is part of the program. Performing procedures in pork or animal protein and using physiological saline solution to simulate the blood flow, they can study the influence of contact force and impedance on lesion geometry etc. and to avoid adverse effects like “plops”. Lots of catheter types are available: 4mm tip, 8mm standard and gold tip, open and closed irrigated tip ablation catheters of different companies. The experiments will be completed by measuring the lesion size dependent on the used catheter type and ablation settings.

Conclusion

In-vitro training in radiofrequency ablation is a challenge for biomedical engineering students and young physicians.
RF Ablation Catheter Tip Material versus Lesion Geometry – The Value of Gold

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Introduction

Radiofrequency ablation allows successful treatment of most supraventricular reentrant and focal tachycardias and an increasing number of ventricular tachycardias. Different catheter tips are used. While AV nodal reentrant tachycardias require catheters with a tip of 4mm length, an 8 mm tip electrodes will be used for atrial flutter. A pulmonary vein isolation will be performed using 4 mm irrigated tip electrodes to achieve larger and deeper lesions. The need of a tubing set and pump for saline transfusion is a disadvantage of this technique. Gold tip electrodes can alternatively be used to produce increases in lesion size. Aim of this study was to compare RF ablation catheters of exactly the same geometry with either platin-iridium or gold tip.

Methods

Gold provides an almost four-fold thermal conductivity compared with platinum–iridium. The Cerablate G flutter (Osypka AG, Rheinfelden-Herten) is a newly designed radiofrequency ablation catheter with an 8 mm gold tip. Its power delivery was compared with the Cerablate flutter of same geometry but platin-iridium tip. Therefore, in-vitro RF ablations were performed using pork meat in a 0.9% saline solution at 37°C temperature. A pulsed volume flow was generated using a pump to simulate the blood flow. Temperature controlled ablations of 60 seconds using 45, 55 and 65°C and a maximum of 70W RF power were performed.

Results

Using the Osypka HAT300smart ablator, cumulative power of 167, 474 and 672W was delivered with gold tip against 121, 227 and 310 W with platin-iridium tip. By the Stockert SmartAblate G4 ablator, 202, 546 and 1075W was delivered with gold tip against 117, 246 and 394W with platin-iridium using 45, 55 and 65°C temperature.

Conclusion

During in-vitro investigations, the gold tip electrodes allowed a in power delivery increase of 117 up to 173%. Thus, gold tips can be used to increase lesion depth and diameter without cooling equipment.
History and Perspective of Radiofrequency Catheter Ablation

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Since direct current high energy shock fulguration was initially performed in the mid 1980s, ablation of cardiac arrhythmias has come to widespread use. Today the most frequently used energy source for catheter ablation is radio frequency (RF). It was the German engineer Peter Osypka who made available the HAT 100 as the first simple commercial RF ablator.

Nevertheless, in the first years of ablation, physicians were effectively working in the dark. Until today with an increasing understanding of arrhythmia mechanisms, both at the atrial and ventricular levels, this curative technology has made tremendous progress. Now, due to crucial improvement of RF ablation generators, temperature and contact force sensor catheters in combination with non-flouroscopic electroanatomical mapping technologies, computerized temperature and impedance controlled radiofrequency catheter ablation can be used to cure all types of arrhythmias including atrial and ventricular fibrillation. For the latter, cooled ablation by saline solution irrigated catheters has been developed to a widely used standard method. This procedure resulting in pulmonary vein isolation requires transseptal puncture and is technically demanding. Nevertheless, it has shown to be more effective than antiarrhythmic drug therapy.

While earliest RF ablations were performed with non-steerable catheters, today are used steerable sensor catheters without or with external and internal cooling and tips of 4mm or 8mm length. Further innovations like integration of mapping and cardiac imaging give exact information of the number of pulmonary veins and branching patterns and help to correlate electrical signals with anatomical structures.

The magnetic navigation significantly improved the success rates and safety of catheter ablation. Thus, in most cases RF catheter ablation has developed in the treatment of supraventricular arrhythmias from an alternative approach to drug therapy into the first therapeutic choice providing low complication rates.

In future, robotic navigation will further simplify procedures and reduce radiation exposure of this curative approach.
Non-fluoroscopic Imaging with MRT/CT Image Integration – Catheter Positioning with Double Precision

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Introduction

When antiarrhythmic drug therapy has failed, different approaches of pulmonary vein isolation are considered a reasonable option in the treatment of atrial fibrillation. It will be performed predominantly by radiofrequency catheter ablation. As the individual anatomy of left atrium and the pulmonary veins differs considerably, accurate visualization of these structures is essential during catheter positioning. Using non-fluoroscopic electroanatomic mapping system with image integration, electroanatomic mapping can be combined with highly detailed anatomical MRT or CT information on complex left atrial structures. This may facilitate catheter navigation during ablation for atrial fibrillation.

Methods

The CARTO XP electroanatomic system was used in a project during biomedical engineering study to practice image integration of anonymized real patients that underwent pulmonary vein isolation by CARTO XP and a MRT/CT procedure. Using the image integration software, MRT or CT images were imported into the CARTO XP system. The next process was segmentation of the acquired images. It involves dividing the images into different regions in order to select the structures of interest. In clinical routine, this segmentation has to be performed before catheter ablation. Then, the segmented images were aligned with the reconstructed electroanatomic maps. This consists of several steps, including selection of the left atrium, scaling of the reconstructed geometry, fusion of the structures using landmarks, and optimization of the integration by adjusting the reconstructed geometry of the left atrium.

Results

In the 3 months lasting period of the project, image integration was trained in 13 patients undergoing catheter ablation for atrial fibrillation. Within this period, time consumption for the process decreased from about 90 minutes at the beginning to about 35 minutes at the end for one patient.

Conclusion

Image integration into non-fluoroscopic electroanatomic map is a sophisticated tool in cardiac radiofrequency catheter ablation. Intensive training is necessary to control the procedure.
Towards Realistic Haptic Organ Phantoms for Medical Training

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Introduction

Minimally invasive robotic surgery (MIRS) promises new surgical possibilities like intracorporal palpation. This leads to a shift in focus of medical training systems, asking for haptic realistic organ phantoms. Todays phantoms consist of homogeneous materials, making it impossible to mimick the complex non-linear viscoelastic mechanical behaviour of biological tissue. As there is no common ground on how to approach this problem, this study discusses objective evaluation methods for biological tissue and is the first to developed a structural model for realistic haptic organ phantoms.

Methods

In this new approach, the synthetic tissue was modelled as a viscoelastic Reuss composite with differen layers of silicone gels and -rubbers, mimicking the liver tissue phenomenologically on a macroscopic level. Based on standardized norms for viscoelastic materials, a new testing protocol for biological tissue was developed. Quasi static uniaxial cylindric compression tests were performed on both, cylindrical bovine liver specimen and equally sized artificial tissue probes in vitro. After identifying the typical behaviour of the liver, the viscoelastic composite was adopted in four testing series.

Results

The newly developed artificial tissue, consisting of a liquid silicone rubber (Shore A=40) and an upper layer of a very soft silicone gel, mimicked the characteristic strain-hardening of the liver successfully during compressive loads.

Conclusion

Medical training phantoms lack the complex non-linear viscoelastic behaviour of biological tissue. In a first step, this study successfully developed artificial tissue to mimick strain - hardening of porcine in vitro liver specimen.
Mannequin based education of biomedical engineers - effects of spontaneous breathing and mechanical ventilation upon other parameters

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Abstract
A mannequin represents a real patient and it allows demonstrating the use of real clinical devices and its effect upon the physiological parameters of the human. We have demonstrated breathing on the mannequin HPS during education of biomedical engineers and blood gases were studied during different types of spontaneous breathing. The mannequin supports connection with mechanical ventilator and it allows demonstrating the procedures that are required when spontaneous breathing fails. We have connected HPS mannequin with mechanical ventilator Avea and demonstrated the effect of mechanical properties of the lungs upon the ventilatory parameters such as tidal volume. The education with mannequin is more attractive for the students that are more involved in the seminars. Direct effect of the ventilatory parameters upon the physiological parameters of the patient can be studied under different settings of mechanical ventilation.

1 Introduction
Biomedical engineers should be able to communicate with doctors of medicine and to solve the problems when medical devices work inappropriately. The practically oriented education is very useful for the students and their following practice. The laboratory of simulated intensive care unit was designed at faculty of biomedical engineering at Kladno for the practically oriented education of the students. The settings of the laboratory is depicted in Image 1. The laboratory contains two mannequins ECS and HPS (Cae Healthcare, USA) and console with medical gases; air, oxygen, nitrous oxide and vacuum. There are also the electrical outlets at the console. The laboratory is equipped with hospital bed Eleganza (Linet, Czech Republic) for the HPS mannequin. Use of the mannequins becomes very popular in the all areas of education, mainly of the medical stuff [1]. Mannequins allow an anatomically correct demonstration of various physical and clinical signs including bleeding, breathing, blinking eyes, etc. and thus increase the fidelity of the simulations. The whole-body simulators are used mainly for the training of the physicians and other medical and technical stuff to work properly in different situations or during increased stress of trained person [2, 3]. The simulator supports list of variable drugs including the anesthetics and it is possible to observe the effect of the drugs that are given to the patient upon the vital functions. It allows that mannequins are also used for the training and further education of the anaesthesiologists [4, 5].

We have prepared some seminars for our students with modern clinical devices such as mechanical ventilator Avea (CareFusion, USA). Our aim is to prepare the practical education similar to the real clinical setting. The exercise prepared for understanding the spontaneous breathing and the effect of mechanical ventilation is described in the paper.

1.1 Simulator HPS
Mannequin HPS represents the anatomical based model of the human. The simulator is constructed to be similar to the real anatomy of the human body. The simulator is controlled by MUSE software. The program is placed in the control computer and it allows control the parameters of the model and even the signs of the mannequin that can be felt. The model consists of three basic parts: respiratory, cardiovascular and pharmacological models that are linked between each other in the similar way as in the live organism [6]. Therefore, it is possible to study the interaction between the elementary systems and study the reaction of the cardiovascular system on the changes in the respiratory part of the model. Blood gases can be analyzed after the

Image 1 Laboratory of simulated intensive care unit with the mannequins.
changes in the breathing for example. Most of the parameters that can be studied are simulated only mathematically in the software part of the simulator. The parameters of the simulator are stored in a log file in the control computer once per four seconds and it is possible to go through the parameters also after the demonstration. The software MUSE (see Image 2) enables setting parameters of the simulator. Scenarios can be prepared and run on the simulator. The parameters of the simulator are changed according to the scenario and the interventions of the trained people.

2 Methods

We have used real medical devices, mechanical ventilator Avea (CareFusion, USA) or anesthesia machine Zeus (Draeger Medical, Germany) that are connected with mannequin during the exercises. We have prepared the scenario in control software of the mannequin. The mannequin starts to breathe, blinking by eyes, etc. after the connection with the control rack. The values of blood gases like partial pressure of oxygen and carbon dioxide can be seen on the monitor and basic vital functions can be measured. It is possible to use external monitor if vital function for measuring of ecg, saturation of blood by oxygen or capnometry.

The breathing is inhibited in the further part of the seminar and it is possible to see the effect upon the blood gases, saturation of the blood by oxygen and other parameters. The students participate on the intubation of the patient, connection of the mechanical ventilator with mannequin and on the basic settings of the ventilator for delivery of air mixture. The effect of proper intubation and connection of mechanical ventilator can be seen mainly on the blood gases values that should reach common values. Similar exercise was prepared with the anesthesia machine where the effect of drugs upon the patient can be observed. It is also necessary to ensure the ventilation of the patient and set the anesthesia machine.

3 Results

We have prepared a few scenarios for the whole-body simulator. The scenarios are used during the education in order to increase the interest of the students about the education. The use of real medical devices and its setting is expected during the scenarios.

4 Conclusion

Laboratory exercises with modern medical devices were prepared for the students. Our experience show that students are more interested about the education and they have better knowledge from the technical principles of the devices, they know better the normal values of the vital function parameters including the units.

5 References


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Medical device incidents reported to the BfArM - What do they tell us about deficiencies in instruction and training for medical device use?

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Introduction

Deficiencies in user instruction and training are considered to be one of the major latent risk factors associated with medical devices. Although the BfArM’s role as the German competent authority for vigilance is mainly focused on the assessment of incidents and risks directly related to possible product deficiencies of medical devices - incidents that result from instruction/training deficiencies are reported nonetheless. Therefore the database of the BfArM lists “instruction/training deficiencies” as root-cause category for incidents. The reports filed in this category were analyzed in this study.

Methods

In 216 cases (150 incident reports/66 corrective actions) that have been evaluated between January 2005 and December 2013 instruction/training deficiencies have been considered to be the root-cause of the incident. These cases were analyzed and split into categories describing the outer appearance of the error to get a first insight into the pervasiveness of the problem across device types.

Results

The 216 cases involve 157 different devices from 69 product categories. 45% of the cases resulted in harm to the patient.

In the majority of categorizable cases, instruction/training deficiencies manifested themselves in use errors directly e.g. when users had problems to troubleshoot minor device errors or to recognize a frequent complication - or when the situation (patient or indication) differed from the standard. In the minor part of cases the user’s expectations mismatched the device functions.

Conclusion

Although based on a specific point of view, the analysis shows that errors due to instruction/training deficiencies present themselves in the BfArM’s database not as a problem of individual devices, but an overarching one. Problems due to deficiencies in instruction/training often show themselves in situations that differ from standard.
An anthropomorphic functional head phantom as a training tool for Intraoperative Optical Imaging

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Introduction

Intraoperative Optical Imaging is a promising neuro-imaging technique to identify functional active brain areas during neurosurgical operations, e.g. tumour resection. This technique is based on the measurement of optical intrinsic signals caused by stimulation of peripheral nerves, to generate spatial high-resolution maps of cortical activity. To introduce this innovative method for clinical routine and to facilitate a practical training system for technicians and clinicians without patients, a customised phantom is required.

Methods

A module for Intraoperative Optical Imaging was designed based on a concept of a modular phantom system. This module consists of a skull contour with a simulated trepanation. In the trepanned area the cortical surface and relevant vessels were modelled. These structures are made of epoxy resin including the dye Orasol Red to adjust the absorption properties and titan dioxide to influence scattering. In addition, acrylic colour is used to offer a realistic appearance of the cortical surface. The optical intrinsic signal is simulated by an integrated light-emitting diode driven by an analogue circuit following the stimulation-induced physiological signal curve.

Results

Using the phantom prototype, the acquisition process of the imaging setup can be simulated and the technical adjustments of that process can be varied systematically. The activity maps generated based on phantom measurements are very similar to real patient data sets.

Conclusion

Until now, the phantom was used for demonstration purposes. Nevertheless, the phantom system is suitable for further application such as training and investigation. Hence, the phantom shall be extended. In this context, the use of deformable material like gelatine or Polyvinyl Alcohol Cryogel should be investigated to simulate cortical movements during image acquisition. Furthermore, the characteristic time course and spectra of intrinsic signals have to be simulated by a time controlled, frequency mixed light spectrum to visualise multiple signal sources within the human brain.
A Practical training course “Technology of Anaesthesiology and Intensive Care Medicine” for physicians

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Introduction
A practical training course is part of the advanced module “Technology in Anesthesiology Intensive Care Medicine” which can be chosen as specialization in the third semester of the online master program Physico-Technical Medicine (PTM). Besides the practical training, the module consists out of an online lecture, which introduces into the theoretical basics, and an online seminar, for which students can choose and intensively work on a certain aspect of this field. The practical training takes place at the end of the semester. The theoretical knowledge of the online phase can be practically applied during this training. The practical training is oriented at the situation of a mechanically ventilated patient where the ventilator, the artificial airways and the patient’s respiratory system build up a pneumatic system of high complexity. To each of the three pneumatic subsystems the students perform at least one experiment.

Methods
The one week practical training was accompanied by preparatory courses of about two hours each, repeating the theoretical basis of the respective experiment. Furthermore a universal measuring system for measurement of respiratory data was introduced in-depth and the calibration of the sensors was the first part of the practical training. The single experiments were: (i) Artificial airways: endotracheal tube. (ii) Respiratory system mechanics: volume-dependent compliance. (iii) Gas exchange: capnography and functional deadspace. (iv) Functional imaging of the lungs using electrical impedance tomography.

Results
The students analyzed offline the respiratory data from the experiments (i) to (iv) using MatLab (R2012a. The MathWorks Inc., Natick, MA) and reproduced results taken from original publications with a general deviation below 10%.

Conclusion
All students who are working physicians unanimously evaluated the learning effect of this one week practical training as to very high and expect an improved personal performance in the daily clinical bedside routine.
Integral Training Simulation System for Spinal Cage Implantation in Lumbar Spine

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Abstract
Interventions in spinal surgery assume a huge amount of knowledge and advanced skills in a wide range of surgical techniques. Especially when setting implants, an intensive training is crucial to navigate multiple instruments with the help of fluoroscopic images. Common training in spinal surgery are guided by experienced surgeons but show disadvantages regarding increasing costs and ethical questions. Furthermore, surgical training techniques are also limited regarding safety aspects of patients and training members. We show in this paper an alternative option to improve intensive training of surgical techniques. In a realistic training operating room surgeons can improve their skills by setting implants in a synthetic-based phantom using simulated fluoroscopic images. The presented system offers the possibility to constantly repeat difficult scenarios. Because there is no dangerous radiation, surgeons can improve their skills in difficult implantation techniques in a safe but realistic scenario.

1 Introduction
Spinal surgeries (e.g. inserting implants) contain a huge range of techniques. Most of these complex interventions are performed in a small but critical area besides the parallel handling of surgical tools and the control of bleeding. Setting an implant to the lumbar spine needs a high level of manual-skills and assumes a distinctive understanding of different surgical techniques. Therefore, reading fluoroscopic images is crucial for navigating implants in minimal-invasive surgeries and has to be trained well.

So far, spinal surgeries are either gradually taught in real surgeries under the guidance and supervision directly on the patient or in wetlab courses on animal spinal preparations of swine and sheep or human cadavers. Both methods show disadvantages. Firstly, concerning the patient safety, as well as high costs, ethical and hygienic aspects and the limited availability.

Furthermore, in trainings X-ray control is usually used only in limited form. Reasons are the high radiation exposure for participants as well as the disproportionate high costs and technical requirements of real fluoroscopic equipment in training centers. Specific surgical steps with the use of fluoroscopic images cannot be repeated well under real conditions.

2 Methods
To solve the problem described above, three components for simulation were designed and developed: the simulation of a surgical site, the integration of a fluoroscopic simulation and the use of a training operating room with an integrated control room.

Synthetic-based training simulator for the lumbar spine: The simulator includes different anatomical structures (e.g. dura mater, yellow ligament, vertebra). To make the simulation more realistic, a three-point controllable bleeding system was integrated: muscular diffuse, laminar and epidural. The bleeding intensity can be controlled by the trainer from latent visual obstruction up to bleeding complication. In addition, the simulator has sensors to measure and display the mechanical strain (tension and compression) of the lumbar vertebrae nerve root.

Fluoroscopy Simulator: By developing a system that uses virtual radiographs to track implants in the vertebral bodies, virtual radiographs can now be generated on the surgical phantom. An optical tracking system measures the position of the disc implant (cage). An artificial fluoroscopic image is generated from a virtual three-dimensional model of the anatomic structure and is registered to the real phantom.

Training OR: The training operating room has three surgical workplaces, each with a surgical microscope. One of these microscopic workplaces transfers images to a HD projector. In order to give proper feedback to the trainees, the training OR is equipped with modern cameras and a control system to monitor the training process. In the control room, the scenarios can be monitored by an analysis of the sensor data and by training videos.

3 Conclusions
The presented simulation system provides to the residents the opportunity to train the entire cage implantation surgery as a teaching operation in workshops. Furthermore, it
improves quality of ergonomics and safety aspects in surgery. The high degree of reality of the surgical site, the integration of sensors in the phantom, the integrated simulated real-time fluoroscopy controls and the possibility to realise a realistic training with supervision by trainers, allow for the first time, besides the realistic surgical procedure, the evaluation of the surgeon’s technical skills during the entire surgical procedure. These is a decisive advantage over existing training concepts, where the learning success in the simulation setting was limited to the teaching of manual skills and the subjective evaluation of surgical performance.

4 References


Man versus machine: Is verbal instructor feedback in virtual-reality laparoscopic simulation dispensable?

Results of a prospective randomised study

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Abstract

BACKGROUND: Virtual-reality laparoscopic (VRL) simulation is effective to train laparoscopic skills. Compared to boxtrainers, VRL simulators have the advantage of providing technical feedback to the trainee. The question arises whether an instructor is needed or whether the technical feedback alone is equally effective. A tailored instructor feedback was shown to have a positive effect when provided for low performing novices. This study was designed to determine whether non-tailored verbal instructor feedback in general has a beneficial impact on novices’ VRL performance.

METHODS: A randomised, prospective, single-blinded study was conducted within a week-long curricular course. A complex bimanual manoeuvre on a VRL simulator was performed by 21 medical students. The participants were randomly assigned to the verbal feedback group (VFG) and no feedback group (NFG). During the training phase, only VFG received standardised instructor feedback in a one-to-one setting. At the end of the course, all participants performed the task without feedback. Knowledge of results and visual feedback by the simulator were provided for all participants.

RESULTS: Analysis of the learning curve showed a significant improvement of all participants ($p<0.001$). No difference in performance was obtained between VFG and NFG at any time.

CONCLUSIONS: Non-tailored verbal instructor feedback does not improve VRL performance of novices.

1 Introduction

Laparoscopic simulation training shortens learning curves of laparoscopic skills. However, a lot of questions about the optimal training methods still remain unanswered. Studies have shown that training with boxtrainers and virtual reality (VRL) simulators is in general equally effective [1]. An advantage of a VRL simulator is the ability to give technical feedback to the trainee [2]. This raises the question whether training with a VRL simulator is sufficient making an instructor unnecessary.

The effectiveness of laparoscopic simulation in combination with verbal instructor feedback (VIF) has been investigated with differing results [3-4]. In general, novices start out at different initial performance levels [5]. To reach educational effectiveness in laparoscopic skills training, such discrepancies should be balanced fair and quickly. Resources for an intensive training of all medical students or novice surgeons including VIF are limited in daily clinical practice making tailored training concepts a reasonable conclusion [6]. A study on tailored VIF for initially low performing novices showed that the learning curve of high and low performing novices can be assimilated quickly [7]. The aim of this prospective study was to investigate whether random VIF leads to a better performance in novices when visual feedback and knowledge of results are provided by the VRL-simulator.

2 Methods

2.1 Study population

As part of a week-long curricular course of evidence based medicine in general surgery in June 2013, a total of 21 third year medical students were included. All participants gave informed consent.
2.2 Task
Students performed the complex bimanual task “Clip Applying” on a VRL simulator (LapSim, Surgical Science, Gothenburg, Sweden) with software version 2011. In a virtual reality environment, a blood vessel should be clipped twice and cut in the middle. During the task, the simulator gave visual feedback with a signal colour e.g. if excessive stress is applied (Figure 1). After the task a detailed report of the performance was presented automatically to the participant (Figure 2). Technical data was recorded by the VRL simulator in the following categories: total time, incomplete target areas, badly placed clips, instrument path length (left and right), instrument angular path (left and right), maximum stretch damage, blood loss, instrument outside view (left and right) and time instrument outside view (left and right).

Figure 1: Task “Clip applying” with visual feedback by the VRL simulator when excessive stress is applied on the blood vessel.

Figure 2: VRL simulator presenting a detailed report of performance.

2.3 Study design

2.3.1 Introduction
After an introduction and demonstration of simulator and bimanual task, students had to perform the task twice without any VIF.

2.3.2 Teaching phase
Students were randomly assigned to VFG (verbal feedback group) and NFG (no feedback group). In the teaching phase, which consisted of six training sessions, all participants had visual feedback by the simulator and knowledge of their results. VFG received standardised VIF during their performance containing methodical, psychological and instrument handling feedback as previously described [7]. The assignment was blinded to the participants and groups practiced at different times.

2.3.3 Control phase
During the control phase, all participants performed the task three times without VIF.

2.4 Statistical analysis
Student’s results were consecutively recorded by the simulator and transferred to a SPSS Database in anonymous form. Performance was measured using the z–score, which is defined as \( z = \frac{x - \mu}{\sigma} \) (\( x \) is a raw score, \( \mu \) is the mean of the parameter; \( \sigma \) is the standard deviation of the parameter). Z-score was calculated for each item measured by the VRL simulator. All z-scores were added up to result in a global z-score for each session. Cumulative learning curves for the VFG (“intervention group”) and the NFG were analysed using the nonparametric Mann-Whitney-U-test. A \( p \)-value < 0.05 was considered significant. Statistical analysis was performed with SPSS Statistics 21 (Statistical Package for Social Sciences program, Chicago, Illinois, USA).

3 Results

3.1 Group demographics
VFG consisted of 10 students (7 females) with a median age of 24 years (range 22-31). NFG consisted of 11 students (6 females) with a median age of 22 years (range 22-31).

3.2 Learning curve
Overall analysis of the learning curve showed a statistical significant improvement of global z-score for both groups (\( p < 0.001 \), (Figure 3).

3.3 Group comparison
Z-scores of VFG and NFG were not significantly different at any session during the initial, teaching and control phase (\( p > 0.05 \), (Figure 3).
4 Discussion

In contrast to boxtrainers, VRL simulators are able to provide technical feedback in form of knowledge of results and visual feedback [2]. The current results state that non-tailored VIF in addition to technical feedback by the machine does not influence the learning curve in novices. Additional VIF has been investigated with differing results. In concordance with our results, a randomised study by Snyder et al. [4] showed that VIF in a complex proficiency-based simulator training over an 8 week period doesn’t influence the learning curve of 32 medical students on LapSim tasks. On the contrary Strandbygaard et al. [3] have demonstrated in a randomised trial that a pre-set performance level was reached faster by the feedback group in a non-tailored concept with 99 medical students. However, these studies used a setup with VIF directly after the training session. Our own former results with a tailored approach showed a benefit of additional VIF for initially low performing novices. These students reached the same performance level compared to initially high performing novices after a week-long course [7]. This study is directly comparable to the present design due to the analogue methodological setup. Interestingly current group comparison showed similar to our previous investigation, that learning curve of NFG has a dip during the 4th and 5th session of the training phase. An explanation may be overconfidence in absence of VIF. Nevertheless, during the control phase performance level of both groups was equal ($p<0.001$).

It seems that non-tailed VIF is ineffective when adequate technical feedback is provided. However, a tailored VIF for low performing novices has a positive influence, which implies selection of participants who will need more than just training with visual feedback and knowledge of results. Such a differentiated approach should also be favoured in order to save human resources [3-4]. On the other hand feedback modalities of the machine could be further improved in cooperation with surgical program directors, educational researchers, specialised surgeons, residents and students.

Our results are limited by the small sample size of medical students and the use of a relatively complex bimanual procedural task on a single VRL simulator.

5 Conclusion

When visual feedback and knowledge of results are provided in VRL simulation, non-tailored VIF is ineffective and dispensable. Nevertheless, feedback of the machine could be improved in a multidisciplinary approach.

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7 References

mobile Augmented Reality in Dermatology

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Abstract

The use of eLearning methods for improving teaching and learning has a long-standing tradition in medical education. Nevertheless, “old fashioned” eLearning modules for medical students often lack the level of experience bedside teaching has to offer. However, for various reasons, bedside teaching is not always an option. For medical specialties where visual information plays an important role, Augmented Reality (AR) based applications can offer a way out of this dilemma. Using AR, it becomes possible to build almost life-like virtual cases that show all desired aspects and have the potential to significantly enhance the learning experience. Current mobile phones and tablets have sufficient power for AR based learning approaches and are ubiquitously available. The AR based mobile app mARble® (mobile Augmented Reality based blended learning environment) is based on this concept and in this paper, we will present results of an adapted study design for measuring the effects of AR as implemented in a mARble® based learning module for dermatology.

1 Introduction

In dermatology, getting a realistic visual impression of the findings a patient presents with is crucial and this also holds true for students who still have to learn how to differentiate between findings as even seemingly small differences in appearance may give clues to the underlying condition. Unfortunately, dermatology is only allotted a relatively small slot in medical education. Thus, it may not always be possible to present all relevant cases to students. The time available for classes may also be a limiting factor.

The integration of Augmented Reality into teaching, which allows mixing conventional teaching with life-like presentations [1,2], may offer a solution for this problem and mobile AR based apps such as mARble® have the potential of becoming part of a digital implementation of the old credo of “See one, do one, teach one”, which fittingly describes the traditional way of teaching practical skills in medical education: it starts out with experiencing a case first hand (“seeing”), goes on to diagnostics and care (“doing”) and lastly passing on the acquired knowledge (“teaching”).

The aim of the presented preliminary evaluation of the dermatology module was to pretest an adapted design of a preceding study [3], where we were already able to show for a module for forensic medicine that learning with mARble® may offer advantages when compared to textbook based learning. This adapted design will be used in a forthcoming study where we will specifically look at whether the advantages we were already able to show in the previous study may really be attributed to AR or whether simply the medium used – ie. the attractiveness of the mobile phone – already causes this effect.

Therefore, in pre-study we present here, we were interested in the feasibility of conducting an evaluation on three time points and whether we could expect any effect.

2 Methods

Fig. 1. mARble® based presentation of a malignant melanoma on a student’s face.

Compared to virtual reality based solutions that simulate the entire environment and thus distance users from reality, figuratively letting them “step away from the environment in which the practice for which they are preparing takes place” [4], AR based learning approaches such as mARble® encourage students to step forward and immerse themselves in an augmented version of reality. Thus, students become actively integrated in the learning process and, by simulating specific findings on their own skin or on the body of a fellow student when learning in a group setting, they have a dual role: they are learners but also learning objects at the same time and are thus firmly inter-woven with a learning scenario that is part of the real
Augmented Reality (AR) is the key technology for linking the virtual to the real world as it allows augmenting reality, i.e., live images acquired from a smartphone’s camera, by superimposing computer-generated content on these images and presenting the resulting enhanced image to the user (Fig. 1).

In contrast to previously used stationary (often PC-based) AR solutions that were often complicated to use and were also limited in that they did not really allow using them “everywhere, anytime” mobile AR-based solutions may significantly reduce these barriers of using AR-based software in teaching medical students due to their ease of use and the portability that is offered by mobile devices. Altogether, mobile AR-based approaches such as mARble® offer an alluring option for teaching and learning, while still taking the real world into account.

With all this in mind, mARble®, a “mobile Augmented Reality blended learning environment”, currently available for iOS, was developed in a collaborative project between the Peter L. Reichertz Institute for Medical Informatics and the Department of Dermatology at the Hannover Medical School. mARble® can be used in many different settings and is applicable in group settings as well as for individual learning or for frontal teaching.

2.1 The Application

Fig. 2. mARble’s learning card-based system for presenting additional information for the current set of findings.

With mARble®, based on data stored in the app’s internal database, it is possible to present virtual cases to students, even for findings that are rarely available in reality.

Learning with mARble® entails using a paper-based marker that contains a specific black-and-white pattern and is placed on the body of a student. The smartphone’s camera continually captures a live-view. Using image recognition methods, the pattern is then recognized in real time and the desired medical finding is triggered depending on the marker’s recognized pattern. The corresponding content can then be overlaid on the acquired image data.

In addition to simply overlaying specific findings, mARble® also contains additional content. For this purpose, mARble® contains a card-based system that can serve to present textual content that can be supplemented with content such as images, drawings, tables, or audio and video files where appropriate. To further support learners, for all texts included in mARble®, voice output (spoken by a professional radio moderator) has also been integrated in the app.

To let students practice what they have learned, for each finding contained within the app, one or more practice questions can be called up by tapping the question mark icon that is shown within the application (Fig. 2). Corresponding answers can be looked up via the information symbol or by simply tapping the flashcard containing the question.

Although mARble’s main purpose is to provide students with an interactive means to “experience” what they have to learn, all content can also be called up via the app’s menu, without using any markers.

2.2 Evaluation

In our pre-study, we included 21 medical students who were in their 3rd (1 student), 4th (3 students), 5th (16 students) and 6th (1 student) of their studies after they had given their informed consent to participate in the trial. Only the 3rd year student had not yet had any classes in dermatology dermatology.

All participants were provided with mobile devices equipped with a preinstalled copy of mARble® and randomly assigned to one of two groups. In addition to the devices containing mARble®, group A was also provided with a set of markers and confronted with the task to interactively “examine” themselves and to make interactive use of the content, while group B did not receive any markers but was rather asked to simply use the app without AR.

The mean age of all participants was 24.8 years with a standard deviation (SD) of 2.2 years (group A: mean 25.4 years, SD 2.2 years; group B: mean 24.2 years, SD 1.9 years). Eleven students of the entire trial group were male and 10 were female. Group A had 6 male and 5 female members while the ratio was even in group B with 5 students for each sex.

As part of an evaluation series for determining learning effectiveness, participants were asked to complete a 10-question multiple-choice (MC) test at three different times during the study.
To establish a baseline with respect to a priori knowledge of the learning topic (pre), all students were asked to answer a 10-question standard multiple choice (MC) test that covered 5 selected topics from the curriculum of the dermatology module at Hannover Medical school (malignant melanoma, squamous cell carcinoma, bullous pemphigoid, psoriasis vulgaris and atopic eczema). They were given 15 minutes for completing this test (10 questions, 90 seconds for each answer). The random assignment to either of the two groups – as described above – only took place after this test.

Group A, the group who was allowed to use the full scope of mARble®, joined the interventional arm of the trial. Each student received a mobile device (either an iPad mini, an iPhone 4 or an iPhone 5), on which the app “mARble Derma” had already been installed, and a set of 10 paper markers. After a short greeting and introduction on how to use the app, with the provided markers and on the learning task, the students were placed in a quiet room, away from group B. The task for members of group A was to learn about dermatology using the provided mobile device on which mARble® had been pre-installed in combination with the markers. Since the students in this group were thus allowed to make full use of the app, including its AR content, this group was called the “mARble” group.

Group B served as control arm of the trial. Same as for group A, each student received a mobile device (either an iPad 3 or iPad mini) and after a short introductory greeting, the group was also given an introduction to using the app, but in contrast to group A, group B did not receive any markers and participants assigned to this group were therefore unable to use the augmented reality (AR) part of the application. Thus, they used mARble® without AR and we therefore assigned the name “mble” to this group. Group B was also placed in a separate room.

For both groups, the version of mARble® that the students were provided with contained all relevant information for again solving the multiple choice test they had already taken previously. Because – as mentioned before – the app also contains audio content, all students, independent of the group they belonged to, were provided with headphones. While learning, they were allowed to use additional supplies such as pens and paper to take notes if they desired. After a learning period of 45 minutes, the students of both groups were again asked to complete the aforementioned standard multiple choice tests (post 1) comprising 10 questions. During the tests, the participants were not allowed to refer to the app or their notes and again, they were given 15 minutes for completing the test.

The third time the participants were asked to complete the MC test was after during a follow-up 20 days after the date of the initial trial. As before, the students were asked to again an MC test containing the 10 same questions as before, but this time, instead of having to come in and do this test on paper, they were allowed to do so in a web-based form from the comfort of their home.

3 Results

Results of our pre-study show, that knowledge gain is greater for the mARble® group (group A) (11/21) than for the control group (group B) (10/21). When comparing the results of the multiple choice tests before and after the learning period, on average, all participants showed an improvement regarding the number of correct answers.

As Table 1 illustrates, based on the number of correct answers given for both groups, the improvement was higher in the mARble group than for those who had learned with “mble” (without the AR) and thus, learning with the full version of mARble® appears to be effective.

At the initial MC test (pre), both groups were at approximately the same knowledge level with a mean of 6.64 (group A) and 6.60 (group B) correct answers. The standard deviation was also nearly the same in group A (1.87) and B (1.91).

After the learning period of 45min (post 1), with a mean of 8.91 (σ=1.05) correctly answered questions, group A had a higher improvement of 2.27 compared to the improvement of 2.1 in group B with an average number of 8.70 correctly answered questions (σ=1.1).

Unfortunately, not all of the original members of both groups responded to our request for participating in the follow-up test, and thus, only 8 participants per group could be included for evaluating the third MC test (post 2). This time, the mean number of correct answers in group A was 9.13 (σ=1) and is thus even higher than what had been observed for this group for the test they had taken directly after the learning period (post 1, mean 8.91, σ=1.05). For group B, the number of correct answers had slightly fallen between post 1 (mean 8.70, σ=1.10) and post 2 (mean 8.13, σ=1.17).

Tab. 1. Average number of correct answers and standard deviation for both learning groups

<table>
<thead>
<tr>
<th>Phase</th>
<th>mARble (group A)</th>
<th>mble (group B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre</td>
<td>6.64</td>
<td>6.60</td>
</tr>
<tr>
<td>post 1</td>
<td>8.91</td>
<td>8.70</td>
</tr>
<tr>
<td>post 2</td>
<td>9.13</td>
<td>8.13</td>
</tr>
</tbody>
</table>

4 Conclusion

Although limited by the small number of participants, the results of our adapted setup seem promising and we are currently in the process of planning a larger scale study
based on this study design where, as mentioned in the introduction, we plan to take a closer look at whether the learning success may really be attributed to the AR aspect of mARble® or whether the effect we noticed in a previous study [3] should rather be attributed to the attractiveness of the medium that is being used: using mobile phones for learning is more exciting than using conventional textbooks. Still, we believe that by making use of the positive aspects of traditional learning settings and adding augmented reality into the picture, mARble® offers an exciting opportunity for improving the learning process in medical education for subjects where visual information is of importance.

A major limitation of the presented pre-study is that there were too many students who had already participated in classes for dermatology and thus, due to their previous knowledge of dermatology, their baseline test results were higher than we had assumed. We refrained from using statistical tests for significance since the effect we observed in the descriptive statistics seemed too low. We had expected an improvement of 2 or more correct answers to be able to test for efficiency of learning. Therefore, in the forthcoming study, we will only include students with no pre-experience in dermatology to be able to still use a relatively small sample size as it will be hard to persuade a larger number of students to participate – which would be needed for being able to measure a smaller effect with significance.

For these reasons, for the follow-up study that is currently being planned, we will try to aim for both a slightly larger sample size as well as for a higher level of improvement by only including students in the first, second or third academic year who do not have any prior knowledge in dermatology.

Still, the available figures demonstrate a slightly better learning success for the mARble® group. This may partly be due to the interactivity required when learning with mARble®. Users have to play an active role in the learning process and cannot simply sit back and participate only in a passive manner as it often happens in normal classroom settings. Thus, they can more easily identify with what is being taught. As shown in our previous study [3], there are some hints about activating and motivating factors of mARble’s AR based concept.

Lastly, an additional benefit mARble® is that due to its nature, ethical problems that may arise when using real-life cases in medical education may be mitigated while still providing students with a realistic learning experience, although mARble’s aim is certainly not to completely replace the use of real cases during classes; however, at least for basic medical education, mARble® is a promising option and offers interesting possibilities.

5 References


