Designing tangible exercises as a means of translating digital concepts for medical students

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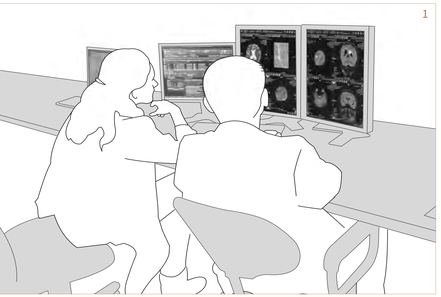
Image
Knowledge
Gestaltung
An Interdisciplinary Laboratory

Background

The design-driven exercises presented below are part of the medical school curriculum taught at *Charité University Hospital* in Berlin, Germany, since the fall semester 2016/2017. The innovative curriculum was developed as a joint project between the research project ***Image Guidance*** at the Cluster of Excellence *Image Knowledge Gestaltung. An Interdisciplinary Laboratory* at Humboldt-Universität zu Berlin (M. Bruhn, K. Friedrich, R. Lauer, M. Queisner, A. Roethe), the ***Image Guidance Lab*** at the Department of Neurosurgery at Charité Universitätsmedizin Berlin (university hospital) (L. Fekonja, T. Picht, A. Roethe), and the ***Medical Futures Lab*** at Rice University Houston (K. Ostherr).

The seminar ***Iconic Turn - How Images Govern Our Actions*** combines the findings and themes from the different research areas involved in the project. The seminar therefore links humanistic / critical, designerly / applied, neurosurgical / medical, and e-patient and patient-centered approaches in order to reflect on changing practices and the potential of medical imaging in neurosurgery.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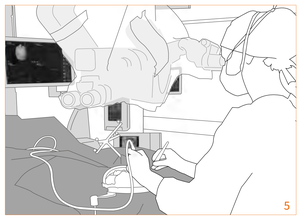
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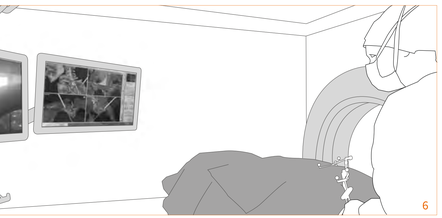
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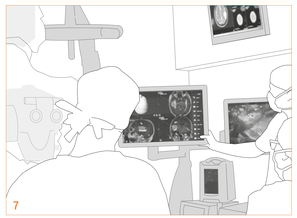
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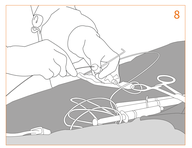
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Objective

The design-driven exercises aim to translate the findings from the observational design research on neurosurgery for med school students and to sensitize and prepare them for image interactions as early as possible. During the field observations, it became clear that ***medical images are connected to very different situations*** such as neuroradiology, ambulances, or intra-operative navigation (Figs. 1-8). All of them require different interaction options from the related software and hardware, and users exhibit different needs and approaches in relation to the use of medical images in different scenarios. The core findings for the exercises developed for the seminar are the following:

1. ***Display media types*** differ immensely. They come in a variety of user interfaces or may even still take the form of printouts of a sequence in some cases. The possibilities for interacting with the images in order to gain a better understanding are therefore limited by the scenario (Figs. 1, 2, 4).

2. ***Surgical practice*** in the operating room (OR) is based on both tacit and tactile (embodied) knowledge. This is clearly demonstrated whenever a surgeon consults medical images on the screen to orient her / himself. The surgeon searches for landmarks and – even if they are invisible on the surface – uses texture resistance to determine where s / he is in the surgical field[1] or which tool would be best for resecting a tissue (Figs. 5-7).

3. ***Disruptive workflows*** occur wherever tools and machines need to be rearranged during a procedure and especially in cases where neuro-navigation is used. At times, image-guided surgery reveals many interaction hurdles because medical images are mostly displayed on non-sterile screens offside of the patient. To position tracked tools in the patient's body, the eyes must go back and forth between the screen, the surgical field, and the surgeon's mental, internal image (Fig. 5-8).

The overall identified aim was to do things hands-on – in an embodied way – that would teach the students a different approach to medical images and foster their cognitive abilities and their possibilities for interacting with medical images.

Method

Why use analog techniques for teaching? – By using analog techniques, we deploy the strong ***hand-eye-head connection for learning and understanding***[2]. The exercises and training for the students in this context are the following:

A. ***Drawing I*** | pen, paper: Introducing students to perspective projection in order to understand how 3D objects can be displayed on 2D media, such as on screen or on paper (Fig. 9).

B. ***Cutting objects into slices*** | hard foam, cutter: Exploring the consequences of cutting an object into slices and seeing how re-derivations from this point to the physical form are possible (Figs. 10, 11).

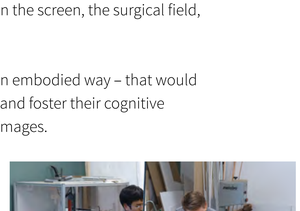
C. ***Cutting multi-material objects*** | flexible foam+«skin», scalpel: Investigating how to cut into objects with different material resistances and how the hole and removed parts can relate to each other (Figs. 12, 13).

D. ***Exploring the layer concept of sectional images*** | cardboard, cutter: Converting a voxel data set of cubes into slices and reconstructing the slices into a frame object so as to understand how flat visualizations of sectional images can be mentally combined into a 3D object (Figs. 14-16).

E. Computer-based ***exploration of 3D models on screen***: Depending on their choice of clinical traineeship and practical year during their studies, the students may have never interacted with 3D renderings of sectional images on the screen before their residency (Fig. 17).

D. ***Drawing II «preoperative planning»*** | pen, paper: The second unit combines all aspects of the first part, *Drawing I,* and the model work: In order to sketch the tumor and the related functional areas, and determine the surgical approach in a given case, students must apply the understanding of sectional images and the ability to mentally reconstruct 3D objects and the spatial relationships between relevant areas of sectional images (Figs. 18, 19).

The application of analog techniques on this level, such as sketching with a pen on paper and cutting different materials, addresses tactile skills and experiences. In this way, ***tactile skills and embodied knowledge*** are subtly presented to medical students ***as epistemic sources***. All of this aims to foster these skills, starting right from the students' training in med school, in order to prepare them for their later residency.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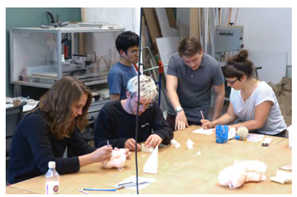
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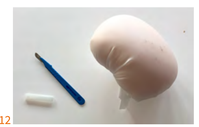
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Conclusions

From students' feedback and our team observations during the classes, the following points can be drawn by way of conclusions and validation of the hypotheses from the field observations:

– Interacting with – internally or with software – and understanding medical images is not easy. In particular, it takes much training for a surgeon to develop and use the internal image and cognitive interactions that s / he will need, and this learning process can start right from med school.

– The practical tasks in the workshop revealed how tricky and non-intuitive the conceptual aspect of medical imaging is. A student exclaimed: «Oh! This is not just tinkering. You have to think for yourself!» This proves that the tasks are not too trivial.

– Student feedback has been very positive so far (based on overall feedback for the whole seminar). We also saw that they understood the rationale for completing these kinds of «non-medical» exercises and how such exercises can help them to make medical images and their applications more tangible and easier to grasp mentally.

References & Image Credits

1- Schueneman, A. L.; Pickleman, J.: ***Neuropsychological Analyses of Surgical Skill***
2- Wilson, Frank R. : ***The Hand, How Its Use Shapes the Brain, Language, and Human Culture***
Petruschat, Jörg (ed.): ***form+zweck: How to Handle Hands?***, Issue 18

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