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Solving challenges in inter- and trans-disciplinary working teams: Lessons from the surgical technology field

Werner Korb[a], Norman Geißler[a,*], Gero Strauß[b]

[a] Faculty of Electrical Engineering and Information Technology, Innovative Surgical Training Technologies (ISTT), Hochschule für Technik, Wirtschaft und Kultur Leipzig - University of Applied Sciences, Eilenburger Straße 13, D-04317 LeipzigGermany
[b] International Reference and Development Center for Surgical Technology (IRDC) Leipzig, Käthe-Kollwitz-Straße 64, 04109 Leipzig, Germany

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ABSTRACT

Introduction: Engineering a medical technology is a complex process, therefore it is important to include experts from different scientific fields. This is particularly true for the development of surgical technology, where the relevant scientific fields are surgery (medicine) and engineering (electrical engineering, mechanical engineering, computer science, etc.). Furthermore, the scientific field of human factors is important to ensure that a surgical technology is indeed functional, process-oriented, effective, efficient as well as user- and patient-oriented. Working in such trans- and inter-disciplinary teams can be challenging due to different working cultures. The intention of this paper is to propose an innovative cooperative working culture for the interdisciplinary field of computer-assisted surgery (CAS) based on more than ten years of research on the one hand and the interdisciplinary literature on working cultures and various organizational theories on the other hand.
Methodology: In this paper, a retrospective analysis of more than ten years of research work in inter- and trans-disciplinary teams in the field of CAS will be performed. This analysis is based on the documented observations of the authors, the study reports, protocols, lab reports and published publications. To additionally evaluate the scientific experience in an interdisciplinary research team, a literature analysis regarding scientific literature on trans- and inter-disciplinarity was performed. Own research and literature analyses were compared.
Results: Both the literature and the scientific experience in an interdisciplinary research team show that consensus finding is not always easy. It is, however, important to start trans- and interdisciplinary projects with a shared mental model and common goals, which include communication and leadership issues within the project teams, i.e. clear and unambiguous information about the individual responsibilities and objectives to attain. This is made necessary due to differing leadership cultures within the cooperating disciplines. Another research outcome is the relevance of a cooperative learning culture throughout the complete duration of the project. Based on this cooperation, new ideas and projects were developed, i.e. a training concept for surgical trainers including technological competence for surgeons.
Discussion: An adapted innovative paradigm for a cooperating working culture in CAS is based on a shared mental model and common goals from the very beginning of a project.
Conclusions: All actors in trans- and inter-disciplinary teams need to be interested in cooperation. This will lead to a common view on patients and technology models.

1. Introduction

Since technology in medicine is becoming more and more complex, human factors engineering is currently an important topic in appendant development projects or research proposals. A wide range of literature on how to perform and design development processes [1,2], manage projects [3] or manage risks [4,5] have been published. Moreover, methods about how to integrate users into the specification, validation and evaluation of products (usability engineering) [1] have been developed. This is necessary in order to be compliant with the IEC 62366 standards [6].

Despite all of these mentioned methods, the implementation of disruptive innovations in the field of medicine is still often disturbed. The resulting systems are either sub-optimal or not used to their full potential. One reason for this defective situation is the

* Corresponding author. Tel.: +49 0 341 3076 3102; fax: +49 0 341 3076853102.
E-mail address: geissler@istt.htwk-leipzig.de (N. Geißler).
URL: http://www.istt.htwk-leipzig.de (N. Geißler).

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fact that developers and user do not share the same knowledge. We assume that both groups could learn from each other if they were part of a cooperative interdisciplinary working group, which could lead to a deeper understanding of the detailed internal knowledge of different professions and disciplines as well as the demands and cultures of different team members. The main purpose of this paper is to find a scientific approach to understand the inherent structures of interdisciplinary and transdisciplinary development teams in the field of medical technology.

At first, a *definition* of our understanding of interdisciplinarity and transdisciplinarity is provided based on the literature [7]. *Interdisciplinarity* is usually understood as working on a common scientific problem with colleagues from different academic disciplines. *Transdisciplinarity* includes two paths with regard to the acquisition of knowledge, which are followed simultaneously: Additionally to the *scientific research path*, which serves to develop interdisciplinary approaches and methods, the *practical path*, which is applied to search for new options of solving societal problems [7], is followed.

In surgical technology engineering, interdisciplinarity is mandatory due to the fact that partners from all different research fields – medicine, psychology and engineering – are involved. Also, transdisciplinarity is important since actors from the application field – in the Leipzig case surgeons, anesthetists and scrub nurses – give additional important input. The engineer and the psychologist are also performing surgeries on simulators. Furthermore, surgical technology industry is often included as a transfer partner in order to partly solve the societal problem of patient safety.

Our observation is the following: It is not only necessary to understand the engineering process itself or to investigate the working domain, product and the technology, but it is also important to understand the psychological and sociological factors of the different team members.

In other areas of inter- and trans-disciplinary research there is a large amount of literature and investigation of those psychological and sociological factors, for example in agriculture and ecology [8], military psychology [9], nanotechnology [10] or the examples provided by Matthias Bergmann et al. [7] regarding demography and supply systems, adapted health services for nomadic pastoralists and situated human-machine communication.

It is important to point out that in inter- and trans-disciplinary research "[. . .] a straightforward transfer from one problem area to another, however, often fails because the individual problem-specific discourse is not adequately understood, neither in other scientific fields, nor in the area of society affected by the problem" [7,p.29-30].

Medical (surgical) technology is a research field that can only be analyzed by good inter- and trans-disciplinary cooperation, therefore the investigation of this topic is of utmost importance. In a presentation on collaborative co-design, Freudenthal et al. [11] started this discussion. To pick up the topic, this paper combines a systematic analysis of more than ten years of research work in computer-assisted surgery (CAS) and a systematic literary review. The analysis of our research work included the evaluation of study reports, protocols, lab reports, publications and a documented discussion of the three authors in January 2013. For the literature review we included the following criteria: (a) problem solving, (b) learning and personal development and (c) understanding teamwork.

1.1. Goal of the paper

This paper intends to give an overview of the literature on inter- and trans-disciplinary research as well as to show practical examples from the surgical technology field. These examples are taken from several projects of the three authors who are experienced researchers in the field of CAS but have different professional backgrounds:

- The first researcher (Gero Strauss) is a surgeon and represents the group of surgeons interested in developing and evaluating medical technology. He is an experienced practitioner and project manager.
- The second researcher (Werner Korb) is an engineer in representing computer science and engineering. He is experienced in the leadership of surgical technology engineering research projects and research teams in different institutes.
- The third researcher (Norman Geißler) is a psychologist, specialized in engineering psychology, human factors and educational science. He is an expert in methodologies for psychological and sociological research. He was in charge for many human factors and educational studies in different institutes in the field of surgical technology engineering.

All three researchers have successfully finished many common projects in the institutions described in Section 1.2.

The goals of this paper are (a) to show the experiences with inter- and trans-disciplinary research, (b) to mirror this experience on further literature and, (c) based on this analysis, to find an approach to develop a new cooperating working culture – an innovative cooperation approach for CAS.

1.2. Inter- and trans-disciplinarity in computer assisted surgery

Based on a first pre-experience in different preliminary single projects in the field of CAS (cf. e.g. [12,13]), the new inter- and trans-disciplinary medical informatics institute (Innovation Center Computer Assisted Surgery ICCAS www.iccas.de, accessed: 4th December 2014) was established at the Medical Faculty of the University of Leipzig in 2005, headed by a steering board consisting of members from the field of computer science and surgeons. The innovative idea behind the foundation of the ICCAS was to address problems of applied research (transdisciplinarity) and investigate them in interdisciplinary teams. The main research area was surgical workflow engineering and the interconnectivity of surgical devices. After the first few years, it appeared that it is most important to investigate the field of human factors in surgery. Therefore, experts from other institutions and universities were contacted for collaboration projects [14,15]. It soon became clear that real interdisciplinary work and higher transformations could only be achieved if the research team in Leipzig integrates (in addition to the surgeons and engineers) human factors specialists (engineering psychologists, educational scientists, etc.). Therefore, a research group within ICCAS started to investigate the human-machine interaction in surgery in 2008 ("assessment of surgical automation systems") (cf. i.e. [16]).

In 2010, based on the experiences of ICCAS, a new biomedical engineering institute (Innovative Surgical Training Technologies ISTT, www.istt.htwk-leipzig.de, accessed: 4th December 2014) was established at the University of Applied Sciences (HTWK Leipzig). The main research area of ISTT is the investigation of human factors and training in surgery. Additionally, haptic high fidelity surgical simulators with integrated sensors and bleeding are developed at ISTT.

As early as 2009, a private research and teaching institute, the IRDC Leipzig (International Reference and Development Center, www.irdc-leipzig.de, accessed: 4th December 2014) was founded, which is financed by a consortium of medical technology companies that operate mainly within the field of surgery. Its main area is applied industrial research. The IRDC is a bridge between research (ICCAS, ISTT and others) and the surgical industry.