Digitizing Health Care in Collaboration Between Nursing and Engineering

Two cases of strategic learning and implementation of robots in the homes of elderly people

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Abstract* - Digitization exceeds the limits of healthcare meetings, which gives renewed relevance to examine the collaboration between engineers and nurses. Caring for people is no longer just something going on in the hospital but at new arenas at home and in the middle of people's everyday lives. In caring situations nurse's responsibility is, unlike the physician, to make observations and to follow in detail the patient's caring needs, and where engineers provide technological devices to support and monitor the course of the disease. When digitizing the caring situation person-centered care gets a new meaning. For engineers the understanding of how technology is contextualized and domesticated becomes even more important to make applications and systems work outside laboratories. This paper presents two cases of interaction between engineers and nurses aimed at improving the implementation of robots and sensors in elderly people´s homes; and learning how to improve patient safety in hospitals. The result shows that conflicting epistemologies, differences in professional languages and lack of joint learning opportunities are factors that create obstacles for interactions. The conclusions reject the idea of linear innovation processes and show that successful ccollaboration take more than just adding two and two together. Especially digitization is breaking up traditional barriers and hierarchies. For nurses to be proactive requires knowledge about technological developments and the ability to participate in design and innovation processes. For engineers a more thorough understanding of caring situations and users will contribute to a more reliable provision of digital solutions and point at new ideas leading up to innovations. The main output of the paper is that it is deepening the understanding of what factors leading to successful collaborations between nursing and engineering and what are the missing links.

Keywords-digitization; caring; nursing; engineering

I. INTRODUCTION

A proposal for a new research subject including nurses and engineers was presented at the Ninth International Conference on eHealth, Telemedicine and Social Medicine, eTelemed 2017 [1]. The background is the fact that today´s health care systems face a number of challenges related to technological developments. The Global Commission on Education of Health Professionals for the 21st Century describes a mismatch between the care offered and people's demands and needs; lack of cooperation; discontinuous care chains; tenacious hierarchies, and not least, a focus on technology founded on flawed understanding of the context in which the technology is used [2]. The gender system that locks structures what perceived as male and female work is deemed particularly difficult to change. Significant is also the lack of good examples of how to meet these types of challenges. Other publications confirm these results, reporting on a lack of accuracy in technological support for health care, not least the confidence in individual solutions. There are reports on an imbalance between the success factors in health care - increased life expectancy and better treatments - and the expectations of what you want done and what to expect [3] [4]. At the same time, the belief in technology as the ultimate solution still prevails. The Swedish Society for Nursing identifies a lack of knowledge about the impact of technology on nursing interventions. To meet this, they emphasize individual health as an important aspect to investigate and call for possibilities to actively participate in design, implementation and assessment of new technology [5] [6]. Others stress the economic value of returning to patient centred strategies [7]. To mention one example, creating digital health care records and digital information to citizens are among the most difficult tasks to accomplish despite the wide access to Internet and digital infrastructures. Google declared a few years ago that their investment in Google Health was one of their biggest failures due to its complexity [8]. Instead they are now developing databases focusing on health and aging sciences.

A. The caring situation in focus

A question that has been discussed for a long time to make development and implementation work is the collaboration between engineers and health care professionals. Ever since C.P. Snow presented his thesis on the two cultures in 1959 stating that "the intellectual life of the whole of western society" was split into the two cultures — sciences and the humanities — creating a major obstacle for solving the world's problems [9], the need for multidisciplinary collaboration has grown in importance. Today there are a number of examples of international multidisciplinary collaboration, e.g., "the Bio design Fellowship program" at Stanford University since 2003 which was also implemented in Sweden as The Centre for Technology in Medicine and Health (CTMH), the Canadian Newfoundland and Labrador Support program, or the Erasmus MC program in Netherlands taking on a patient perspective, just to mention a few. These types of commitments are key elements in promoting interdisciplinary research and development in medicine focusing problem-solving in general between stakeholders, health care professionals and patients.

However, it is rare to find evidence for how to create successful collaborations focusing the caring situation including nurses and explanations to why this is difficult to achieve. Biomedical engineering and clinical trials are for the most part related to doctors collaborating with engineers. Lately the need for nurses to be involved is discussed [10]. especially when it comes to teamwork [11] [12]. Inter-professional collaboration during education is pointed out as a good opportunity to overcome professional barriers [13]. and some experiences published [14]. This is especially asked for in times of increasing specialization [15]. Beyond this, interventions into caring situations and nursing are for the most part about studying them, interviewing them about their work environment [16] [17] [18] [19], musculoskeletal disorders or other physiological problems in working life [20] [21], job demands [22], exposure for abuse or other risks [23] [24] [25] [26] [27], workload [28] or to prevent or plan for interventions [29] [30] [31]. Interventions with a participative approach include e-training programs [32], ergonomic preventative programs [33] [34] or integrated care [35] or are discussing success factors for interventions in nursing in general [36]. However, there are no conclusions about what limits multidisciplinary collaborations or what makes it possible.

When turning the health care meeting, or caring situation, as it will hereinafter be called, into the research object and focus for this paper we do not include any health care professionals. The caring situation is defined as the situation where nurses and biomedical engineers are both interfering with caring for the patient. Unlike the physician who is responsible for making diagnosis, it is the nurse who has the responsibility for the caring situation. Nurses are making observations following in detail the patient's caring needs and providing relevant and sufficient care while engineers provide technological support for monitoring the course of the disease. In a critical situation where technology fails or the patient status changes in an unexpected way, engineers immediately start to search for technological problems while nurses immediately direct his or her concentration on the patient. This is good and well and according to their training and competencies, but at the same time they interfere with the same patient and in the same situation, and not least in connection with digitization and implementation in new arenas. One can assume that their interaction and communication is a vital factor that influences the outcome of critical situations and the patient's wellness. Furthermore, digitization provides us with new challenges and opportunities to examine the collaboration.

B. Engineering and nursing when digitizing

The initiative presented in this paper takes place in the era of digitization and digitizing health care is the overall context in which this is under development, in fact one of the most important advances, compared to when the healthcare system developed on a scientific basis [2]. At that time, modern science was integrated in medical training leading up to reforms and knowledge that doubled the life expectancy during the 20th century. Today digitization encompasses bio-medical engineering used by health care professionals in hospitals, and home health care systems, as well as digital tools used by both health care professionals, citizens at home and in mobile settings.

Engineering and nursing, including caring sciences, have a long history together in developing modern health care. While engineers have provided tools and instruments in accordance with technological advancements, nurses have had the role as users of these applications in patient contexts and have been responsible for the safety around the patient. In this context engineering includes technical research across the borders of engineering and medicine important to medical applications and health care in its widest meaning encompassing research on cellular and molecular level to complex systems and materials and energy. Traditionally, doctors at hospitals are pointed out as the target group for medical technologies. With digitization breaking up hierarchies there are reasons to point out other health care professions beyond the role of the doctors, nurses having a central role close to patients.

In the Nordic countries, nursing as a research subject, have for thirty years, developed in parallel with "caring sciences". Both have been expansive including caring informatics and caring theory. Nursing, which is the broad international field, has its focus on guiding nurses in practice such as routines and regulations and patient safety. Caring sciences, published in Journals, such as the Scandinavian JN for Caring Sciences among other JN, originate from phenomenology and the interest to understand principles for utilization [37] [38] [39]. Caring science is today related to person-centred care, self-sufficiency and independence. Especially since the core of caring has been revealed as central, holistic, individualized and at the same time providing expert physical care combined with fulfilling emotional needs in an adaptive environment [40].

Digitization takes place in parallel with another characteristic of our time - demographic developments – in fact the most contemporary social change of our time taken place today in most parts of the world. Drastic reductions of child mortality and increased living standards in developing countries have increased the average life expectancy. Children and old populations constitute the groups that will increase the most until 2050, hence being the main patient target groups for the coming decades both locally and globally. It is estimated that within a decade, the majority of the world's population will have accesses to virtually all the world's information in a machine that fits in its own palm. These profound changes occurring within one generation naturally has a great impact on digital media, robots and sensors creating new opportunities to practice disaster response and care, in dangerous situations and in the monitoring of health.

In this paper digitization is understood in its historical context being an extension of the use of IT, converting even more information into digital form. The telephone system used by broad groups of citizens is one example of an everyday technology with multiple uses now being digitized. A long used technology is the safety alarm that has been in operation in home care since the 1970s and now being digitized. There are good reasons to assume that previous experiences of use and technological changes affect individuals approach to new technologies. Following the classic theory of Everett Rogers, adoption is a process that deals with the uncertainty in deciding about a new alternative to those previously in existence [41]. From this theory the widespread use of the safety alarms can probably be explained by the long experience of using telephone applications. Second, digitization occurs in everyday life, not in limited and controlled environments, since exchanges between people are mediated digitally to an increasing degree. This provides more complex challenges since most of medical technologies traditionally are developed and tested in laboratories away from real life settings. To understand why digital applications and systems do work or do not work in people´s everyday life requires a subtler and theoretical understanding of contextualization of technology and domestication processes.

Hence, with digitization we refer to the on-going development of mobile and virtual communications between hospitals, homes and caring units moving focus from hospital- and function-based organizations to personalisation and new arenas for health care. In other words, from talking about health care in terms of patients, diseases, wards and elimination of risks with single technical applications, towards a focus on health, home health care such as cancer and palliative care, monitoring and communication on distance, digitized and accessible patient care records requiring active patients and citizens and more of inter-professional collaboration and teamwork between health care professionals. These shifts in the way care and contacts with citizens are understood is already underway applied in a wide range of ideas but less supported by empirical evidence.

Digitization will definitely challenge the way engineers and nurses interact, both in real life caring situations but also in developing and implementing digital health care. For digital applications to be supportive in local practice it is dependent on engineering competence but also relevant implementation outside laboratories, in real life settings, and situated caring competence provided by nurses in close collaboration with patients. On the other hand, digitization offers new opportunities to collaborate in areas not yet occupied by any specific interest. The potential to improve collaboration is still embedded in the interaction between technology, user experiences and the way the context is organized.

C. Patient´s new role

One of the most important areas today in which inter-professional and multi-disciplinary collaboration is crucial is the implementation of telemedicine for outpatient care including system design for monitoring, design of care robots and applications for self-care. This development has a number of consequences, primarily a further shift from in-patient care to caring activities outside hospitals and for engineers the challenging transition moving new applications from the laboratory out to practice. The patients themselves have become an indispensable factor in making the systems work, since the implementation of digitized home health care is taken place outside controlled hospital environments and laboratories. This in turn implies understanding the domestication of technology and awareness of the environment and the situation where the systems are supposed to work. In addition, these systems are increasingly complex. The way to understand technological worlds and social worlds has long been perceived as "socio-technical systems. Factors that help coordination and adaption in complex socio-technical systems have been brought forward such as shared visions and common goals [42] and active learning environments [43] [44]. The traditional way to apply already made technology is criticized for being unaware about the social context and the human being exposed to a more or less deterministic development [45] [46]. One reason is that technology evaluated as onedimensional building on a linear model of innovations makes recommendations that are underestimating complexity [41]. Consequently, it is hard to find empirical evidence that implementations benefit from linear systems. On the contrary, it is estimated that two-thirds of organizations' efforts to implement change fails [48]. For these reasons it is suggested that one must leave the linear model and consider all factors that influence implementation [49]. Actually, this is a point where multidisciplinary collaboration is needed based on a more informed and critical perspective on innovation and implementation. From an engineering point of view, mathematicians can contribute to a more non-linear thinking by providing the central distinctions between linearity and non-linearity. A broad range of researchers in caring science and social science can contribute with empirically justified concepts of the role of technology in human contexts by providing concepts such as domestication, behaviors and context.

So far, however, the uptake of digital technologies designed for patient centered care and use implemented in people´s everyday life [50] has remained disappointing. They typically run up against acceptability problems and widespread non-use when they meet the muddled realities of everyday life and complex market forces. Their interventionist potential has not been realized because the complexities are both under-theorized and over-instrumentalized [51]. For children in long-term intensive care the needs for design that allow them to live an active life are crucial. For example, children with respiratory disorders in need of carrying around oxygen equipment at home are still to a great extent discriminated by heavy and stigmatizing design. The same goes for elderly people. The way the most common technologies provided by home health care reflects images that these users have very low expectations. In fact, this can be experienced as stigmatizing [52]. At the same time investments in systems to meet increasing needs in health care to provide help and support for ageing populations aiming at facilitating for elderly people to stay in their own homes as an alternative to nursing homes are huge. European Union invested more than €1 billion euro in research and industry collaborations in long-term monitoring in combination with robots in the homes of elderly people between 2008 and 2013 and continues to do so in Horizon 2020.

D. Digitization goes beyond single applications

Digitization in this paper is framed in the discourse of eHealth, implementation and learning, understanding digitization as leading up to a greater complexity and especially for engineers, a new sometimes puzzling context coined in terms of implementing technology "out in the wild", outside the laboratory. We are entering a new phase where it is more about interconnected systems and no longer just individual applications. Today, the use of different types of IT applications is not unknown to anyone in health care. Examples of products that can add value are digital patient records, alarms, and sensors for monitoring health, robots with various appearances such as social robots and rob cats, digital incontinence indicators, and remote surgery, decision support for diagnosis and balance training for stroke sufferers. Many of these examples have been shown to increase the quality of care and have already become successful business solutions. At the same time, this raises awareness about the fact that individual technical artefacts are hardly the solutions to the health care problems. This leads to a number of questions which need to be addressed: How can we permanently and sustainably integrate new applications in health care? What is the best way to implement accurate solutions in health care with a comprehensive and ongoing digitization?

Another important question concerns what is called the technological imperative in relation to caring values: are we always obliged to do what can be done in terms of technological development? Or can we find ways to criticize such deterministic views? Although technology is closely associated with the development of modern medical care, the relationship to technological development is divided [53]. Here is a criticism that high-powered specialization risks creating problems can become counterproductive. The German philosopher George Henry Gadamer asserted, for example, that it is precisely in highly developed technical civilizations that the phrases "quality of life" and "whole" are expressed, because something is lost. A narrow technical perspective sometimes tends to give healthcare professionals the role of managing technology instead of people. It also contributes to the technological imperative, i.e., what is possible to be measured must be measured even if the benefit is unclear. Meanwhile, with a critical perspective on technology development, we can see its growing importance and that it is a force for change.

To sum up, while engineering understands the increased complexity, patient context is more familiar to nurses. As digitization increasingly moves in to the realms of health and self-care, the relationship between the caregiver and the individual citizen, patient or care receiver, becomes more important. In order to successfully implement and promote self-care management, personalized medicine" and consequences of the demographic development this paper will contribute to open up the "black box" providing new findings from the inside of collaboration and learning activities between engineers and nurses [46] [55].

E. Aim

With this background, how much can we expect engineers and nurses to collaborate and what can be defined as factors leading to successful interactions and what are the obstacles? We can assume that collaborating in order for the patients and citizens to benefit from digitization and be safe and cared for in a relevant way both inside and outside hospitals encompasses both common interests but also potential conflicts. These conflicts can be of a more general nature such as differences in understanding technology and its role in caring situations, power relations in providing and receiving care and how to influence technological developments, as well as more specific context dependent conflicts for example personal relations.

More precisely, how do engineers understand the caring situation and how do nurses understand technology in caring situations and what makes it work? How does this interaction take place in research and development projects and how can this interaction be prepared for and facilitated already during education and training?

This paper aims at deepening the knowledge on collaborations between nursing and engineering; what are the factors leading to successful interactions and collaboration and what are the missing links? What are the challenges considering the practical context in which digitization takes place and asks for successful implementations as a result of multidisciplinary collaborations?

F. The structure of the paper

This first section, which is an introduction to the empirical results presented in the next section, has shown how digitization is characterized more by systems and complexities rather than individual artifacts, and therefore requires enhanced collaboration between engineers and healthcare professionals to get systems to function outside the laboratories and outside hospitals, in the homes of patients and caregivers. Section II provides the empirical result from two cases. The first paragraph presents the result from an in-depth analysis of the collaboration between engineers and nurses in two European based projects on robotics related to health care. The second paragraph presents the evaluation of joint learning activities between engineering and nursing students during their last semester. These activities were taken place as pilots to develop a strategic program in collaboration between Royal Institute of Technology (KTH) and the Swedish Red Cross University College (SRCUC) and the new subject: Technology in Health Care. Both cases are original research elaborating on what are the common interests and existing conflicts between nursing and engineering when implementing and evaluating new technologies in caring situations. Section III discusses this result and methodological weaknesses and strengths related to the cases. Section IV provides conclusions of use for future engineering-nursing collaboration.

II. EMPIRICAL FINDINGS IN TWO CASES

Result from two empirical cases is presented including methodology, research design and result. Targets groups for both cases are engineers and nurses in collaboration and their relation to patients in caring situations.

A. First case: implementing robots and systems in elderly people´s homes in joint collaboration between nurses and engineers

1) Methodology and research design

The first case is a meta-analysis of two research and development projects funded by the European Commission within call FP7-ICT-2011-7. The project GiraffPlus was aiming at the implementation of a system with sensors and a tele robot (half autonomous) for monitoring health care needs and communicating with health care professionals and municipal home help services. The second project, HOBBIT, was aiming at a robot companion to help elderly people at home picking up things from the floor, retrieving glasses or medication or call for help in case of falling. From these projects, which lasted for three years, there are a lot to learn even though the projects in themselves had a limited time to make changes that affected the project plan including project goals and the level of ambition.

The analysis is based on a review of critical situations that emerged during the work and demanded a joint discussion in the project teams or any kind of change of plans. The critical situations that were defined derived from projects combined and their protocols, notes from meetings and from the on-line bug trucker. The critical situations discussed in protocols or in notes from meetings or pointed out as problems in the on-line bug trucker were organized in line with the project plan including developing ethics and ethical vetting; catching needs in scientific literature reviews; translating needs into technological applications; laboratory tests; tests in the homes of elderly people; and exit strategy.

The competencies involved a number of professional actors but for this analysis engineers and nurses and patients were selected as focus points. The projects were organized in different ways. Test sites were organized in seven homes in the HOBBIT project in three European countries and in total 15 homes in three countries in the GiraffPlus project over periods from three weeks up to eighteen months. While HOBBIT were centrally organized with one coordinator for all tasks and engineers moving around to different partner countries with different test sites, the GiraffPlus project were organized in test site teams in each of the three partner countries being responsible for in total fifteen the test sites. The test site teams had regular contact or immediate contact in case of emergencies or technical problem. The test site teams included four functions: managing the project, coordinating the system, contacting users and solving day to day technical problems. Half way into the GiraffPlus project an online bug trucker was installed in the report system managed by the test teams to get a better overview of what kind of problems that the elderly users encountered. The on line bug trucker registered technical bugs and other test site problems i.e. in the homes of the elderly users. In total five engineers and two nurses were part of the HOBBIT project and six engineers and five nurses in the GiraffPlus project.

The elderly participants thus had a central role in the planning of both projects being involved in every step of a user centric development cycle. They were selected as primary users and asked for participation on the basis that they met the following inclusion criteria: being 60 years or older; willing to try out a robot in the home for three weeks in the HOBBIT projects and 6-12 months in the GiraffPlus project; living in their own homes, not in a nursing home or sheltered home for elderly people; being frail with walking instability and risk of falling and feelings of being insecure; at least one chronic condition such as: diabetes, high blood pressure or cardiovascular disease; and being on medical treatment (taking pills). Not having any diagnosis such as dementia or other cognitive disease was an important exclusion criterion. Their participation encompassed tests of a variety of products in a laboratory related to the monitoring system such as blood pressure measurer and remote controls for the robot. Second, they were having a monitoring system with a telerobot in the GiraffPlus project or a mutual care robot in the HOBBIT project installed in their own homes.

2) Result: Common interests and conflicting epistemologies

The results show that critical situations appeared in relation to problem interpretations and to the need to develop and follow ethics approved, catching and translating needs when designing robots and tools, finding test sites, conducting field tests and in the end, withdrawing from the homes, the exit strategy. These critical situations did not always bring about changes but exposed conflicting epistemologies and how they affected implementation and involvement of users. To solve these dilemmas without risking the progress of the project it goes without saying that the participants completed the project being in for different reasons. Four critical situations, or epistemological gaps, were found:

a) Cultivating images of elderly in need of technology

In the first category, we learn something about the validity of the project result, namely that the input engineers needed, despite the user-centered approach were more often guided by their images of elderly rather than of what the older participants in the project expressed. This was confirmed in a master thesis published in August 2017 within this KTH-SRCUC program [56]. The aim of using a user centered design approach was to ensure active involvement of elderly users during the entire development cycle ranging from the analysis, observation, design and verification phase in order to catch the most relevant needs of this target group. This was an important requirement for getting funding for the project. For this reason, their involvement as such was legitimizing the project.

However, to what extent did that lead up to catching relevant needs? One of the first tasks was to map out scientific evidence for elderly people´s needs of home health care systems as a base for making the first questionnaire before testing in the homes. Results of a literature review in the GiraffPlus project was reported in the first delivery to the EC and followed-up twice compared with what the elderly themselves asked for along the way. It turned out that the result from the literature review was not confirmed by the elderly persons who tested the technology in their homes. There was a lack of useful concepts to catch context-based factors and experiences. It turned out that the relation between individual physiological and social needs related to single applications did not match with what the elderly users tried to convey. For this reason, the project ran the risk to continue to be shaped by stereotypic views of elderly rather than broadening the understanding of aging and later life in a technological landscape. Also, the elderly themselves seem to refer to stereotypic views when they most often said that the technological solutions that was presented probably would be useful for other elderly but not for themselves.

b) Being in for different reasons

Second, we learn that engineers and test persons can be in the same project and perform tasks in parallel but with very different reasons. Both the engineers, social scientists and health care professional were motivated to participate in the project out of their scientific perspective or engagement in certain questions. The main objective was to develop or study the communication and information transfer between patients in their homes and their health center (physician, nurse, physio therapist or occupational therapist) using robots and sensors. The goal was to make this contact more efficient, but not necessarily to give more opportunities for personal contacts. However, the reason for the elderly to be a part of the project was exactly that, to gain more contacts with health care and a feeling of being watched over and taken care of. The presence of project people going in and out of their home even became too much for one person who dropped out, but many of them expressed expectations to be more in contact with the health center as a result of the project. To conclude, while the engineers tried to rationalize contacts and ease the burden for health care providers, the elderly users saw this as a way to gain more contacts with health care. It can be added that the ambition of rationalizing contacts would have required re-organizations of doctor's routines and health care organization that was beyond this project.

c) Making robots work

Third, testing communication between the elderly person at home and the robot itself was the main objective for the HOBBIT project. Also for the GiraffPlus project there were possibilities for the elderly person to self-initiate a communication, for example in emergencies, in need for rehabilitation with support from a physio-therapist; or getting virtual visits from a nurse. To create systematic dialogues possible to evaluate, engineers used scripts i.e., predefined dialogues and behaviors, that test persons were supposed to follow. In the GiraffPlus project hardly anyone initiated the robot. In the HOBBIT project tests with script and users focusing a situation were tested in a laboratory, trying out for example the need for entertainment or asking for help picking up something.

What happened in the GiraffPlus was that the wider context interfered; a domestication process took place meaning that the robot became a part of the social context at home including routines, habits and the moral economy of the household [57]. While scripts made them isolated from their social context, the robot became meaningful when it was given a name and became a symbol for the elderly persons being part of the most advanced technological progress. As a consequence, one of the most important aspects for them was to make sure that visitors could see the robot and learn about their participation in the project. From this experience it can be questioned if the script tested in the lab would be possible to be implemented in the home in the way it was expected. To conclude, while the engineers were trying to predefine dialogues and behaviors, the domestication process that took place in the context of private homes alternated the result given in a laboratory. With domestication, elderly users came to use and evaluate the technology in different ways. An assessment of how useful the new technology was in relation to what they already had led to lower or higher usage. If it was easier to call the phone instead of getting connected to the telerobot this is what they did. Another example is how visible one wanted the new technology to be at home, which had consequences for where it was placed. Another example was how well the new technology could be adapted to daily routines. One refused to use it if it was inconvenient and made everyday life more complicated or even intrusive. This might be the most obvious proof of the difference between controlled laboratories and people’s social world and the factors which affects implementation.

d) Making them ours

Fourth, the project aims to define relevant applications and make technology work was overshadowed by the fact that the elderly participants put great emphasis on the robots' appearance. The initial workshops about what to use a robot for and its design and appearance engaged groups of elderly persons invited to draw pictures and discuss these matters. Already at these workshops it was obvious that the appearance of the robots engaged more compared with technological functions. As part of the domestication process these artifacts turned into family members. Other signs of domestication were that the robots were given names and that the elderly users tried to fit the system as much as possible into their daily life, meaning as few changes as possible. One example was the refusal to be micro-managed, i.e., that their behaviors were monitored just for the interest of the project.

Three design briefs of potential robot appearances were developed and tested in three countries. With reference to the project's limited time and funding it was not possible to test a variety of prototype appearances, but the picture was commented on by the elderly as an important part of the interior style of their homes. One can assume that this affected their use of the robot and their assumptions about having such a “machine” at home. With this background, one plausible assumption is that while the engineers were focusing technology, the elderly users focused on the looks of the robots.

B. Second case: joint learning activities for engineers and nurses preparing for technological hazards

1) Methodology and research design

The second case is about preparing biomedical engineering students and nursing students for collaboration in caring situations in which these two professional groups will meet and handle any risk and hazard that might occur when caring for patients. Testing this joint learning initiative has two aims: to improve communication between them and to make them more proactive in, not only avoiding risks but also in taking part of technological development and collaborate around producing new applications and innovations to secure patient safety.

This learning activity took place within the collaboration between The Royal Institute of Technology, KTH, and Swedish Red Cross University College, SRCUC, in Stockholm Sweden, implemented in parallel with a new interdisciplinary postgraduate program and teaching subject - Technology in Health Care (in Swedish: Teknisk vårdvetenskap). The Nursing Science program at SRCUC will therefore have the potential to add a unique technological profile to its 150-year tradition of training nurses. At KTH, the Department for Technology and health will be given new opportunities to implement new technologies in health care successfully and to improve its research on how technology works in caring settings. Three goals was set in 2014, in the beginning of the strategic development: 1) to better understand medical technology, safety aspects and functions; 2) to increase the ability to proactively participate in the development, implementation and evaluation of technology; 3) to understand how technical developments affect professional roles and working methods. One strategic meeting point early defined was between engineering and nursing students.

Preparations for learning activities of which one is presented in this paper include publications focusing patient safety, learning and innovation. The first articles in this context were published by Mattsson & Stevens [54] [58] and Björling on coated endotracheal tubes and central venous catheters with focus on patient safety [60] [61]. During the same period Östlund published several articles on innovation processes, design and ethics especially dedicated to the use of robotics in elderly care [62] [63] [64].

The first attempts to joint learning opportunities for engineers and nurses took place in 2016 and was followed up 2017, conducted in collaboration between teachers from KTH and SRCUC. The exercise is organized as a part of the curriculum in which students in nursing and students in medical engineering meet for a joint activity during their last and sixth semester of education, in total 80 students participated. The starting point for the joint exercise was the caring situation where they both have their professional roles but rarely access to each other's perspectives. The education goals were to increase the understanding of each other's way of approaching a caring situation with advanced medical technology, more precisely to increase the understanding of each other's perspectives, competence, tasks and way of communication; to start to communicate with each other; and to solve a problem that is supposed to be as realistic as something they will approach as part of their future work situation.

The work material consisted of a report from the Swedish Accident Investigation Authority about a serious failure at a Swedish hospital causing the death in the cardiac intensive department in 2010. This accident was the object for an investigation published in an official report [65]. The students prepared themselves before the exercise by reading this report. They were also prepared with the theoretical model of a "Man-Machine-Organization" model which were a part of both nursing and engineering educations. The exercise took place during one day and gave them the opportunities to elaborate on the education goals in groups, presenting the result of the group work for the entire group and to make an individual statement of the learning outcomes.

A total of 59 students participated in the workshop in 2016, whereof 39 engineering students and 20 nursing students. When giving the same workshop with a new set of students in 2017 a total of 69 students participated, whereof 39 engineering students and 33 nursing students. At both workshops all students were asked to voluntarily hand in an anonymous written reflection about the joint workshop described above. They were asked to evaluate the activity by responding three questions: 1. What are your views on patient safety after today's workshop? 2. What are your views on collaboration between biomedical engineers and nurses after today's workshop? 3. What did you learn from today's workshop? All students handed in their evaluations.

2) Result

The result of this joint learning activity gave overall very positive result, which is a conclusion drawn from anonymous written evaluations the same day as the exercise took place. The most referred experiences were that this was educational and surprisingly interesting to deepening the understanding of nursing respectively engineering perspectives. Common insights were that technology is an important support but dependent on the way it is organized and that there are no unrelated actions that does not have consequences in such a situation. Critical comments asked for more preparations and the need for follow ups out there in real working life.

If we consider how this activity affects long-term collaboration between engineers and nurses, we can say that the result proves that they have gained new insights in professional jargons and not least the awareness that there are other professions involved in making the caring situation into what it is. Both these groups will in a few months meet out in the labour market. They have no problems to find employments since there is a shortage of both nurses providing care and engineers working at hospitals with providing equipment and support for surgery and a wide range of follow-up health care activities within the responsibility of hospitals. But at that time it might not be possible to create the communication that in this case is provided already during the education. The possibility for joint learning activities between nursing students and medical engineers during their education will broaden their understanding, enhance patient safety and ensure a sustainable care.

III. DISCUSSION

This paper is looking for factors leading to successful interactions and collaboration between engineers and nurses and what are the missing links. While such collaboration is taken for granted as something that will automatically lead to more useful technologies and implementations and no one opposes such an approach it is rare to find explanations to why it works or does not work. The results reported in this paper point to the lack of a common understanding of what creates successful implementation and why the results of testing of products in laboratories cannot automatically be transferred to real life settings without taking into account the user´s expectations, skills and social contexts. This is described in the analysis as engineers and nurses have different epistemologies.

Engineers expect laboratory testing to be a reliable method to make technological products work outside laboratories, while nurses are expected to learn to use the technological devices that they are provided with by engineers. Both groups under-estimates the domestication processes that takes place as a result of the interaction between new technologies and user´s in real life contexts and interactions happening in caring situations. Nurse´s experiences of using technologies in caring situations was not counted as part of their technological competencies or at least not asked for when prototypes were developed and testing was planned. Neither did the nurses see themselves as part of the technological development. It was the engineer´s responsibility. The nurses relied on published result on what factors are of importance for independent living in relation to daily activities.

The key user group – the elderly users involved in the projects described in this paper – constitutes a third collaborator that also brought in their expectations and which turned out to be quite different from the nurse´s and engineer's expectations. The elderly users can be described as being "implicated" users or "lay end user", meaning that they are talked about and involved in responding to interview questions and even observed in the home, but still not involved in modifications or design [66]. It seems as if engineers, nurses and elderly users can be involved in the same development project but for very different reasons. It can be assumed that there are hidden aspects not properly explored in this design process that might be innovative. The relationship between these three collaborators could for example be studied in terms of power and who has the advantage of formulating problems and solutions. That would probably reveal more of these mechanisms of why they were in for different reasons.

Besides the four critical situations that are described in this paper and that reflect the phenomena of being in for different reasons there were also other findings pointing at elderly user's context being invisible even though they were supposed to be at the heart of the project. They were aspects related to safety and security. Since security is well linked to transfer of information and private data, more or less unknown aspects occurred with the implementation of technologies in the homes, such as the capacity of the infrastructure that caused severe interruptions; the interios design and furnishing not adapted to robots moving around; the social context having its own routines which was interrupted by the system and sometime experienced as intrusive.

Digitizing health care places new demands on a long-established organization of engineers being employed at the medical technology unit and nurses who have their main workplace with patients at the ward. With digitization it is no longer enough for engineers to provide and manage the technology at the hospital and nurses to learn to use individual machines. Now health care is taken place with new involvements of patients and at new arenas in people´s homes and on the move. The result challenges the way innovation processes are normally organized as linear, putting two and two together under limit time pressure and predictable outcomes. For engineers this will probably widen their scope from the hospital to environments outside the hospital and for nurses it will generate new tasks and new professional roles such as partake in distance surgery, keeping in touch with patients at home via robots or being genetic guides for patients finding out about their health heritage. Already comprehensive investments are in motion where engineers and nurses are supposed to collaborate around design and implementation and tests.

Being in for different reasons tells us that a deeper analysis of the actual collaboration and critical situations in joint projects show where the limitations are. It is not about testing the design of interfaces only or pre-decided effects of using certain devices. Neither is the result of implementing lab tested technology in real life settings predictable. What makes a difference are factors such as the expectations of user's ability, very often concluded from generalized user requirements leaving out the context. Second, user's own expectations, in this case they were not interested in the robot per se but to be involved in frontier project and increase contacts with health care. Third, it is what´s in it for me that makes the domestication process successful, not technological imperative such as monitoring behavior and involving relatives just because it is possible. These findings challenges both engineering and nursing paradigms since it is not about patients only or not about technology only but about the interaction and the caring situation.

These findings should be of interest for policymakers and planners of research and development programs on national and European levels when elaborating on what should be the criteria for investments in future home health care systems. In connection with the discussion of an aging population and the potential of technology, these results are important in understanding what can make a difference. For engineers these results can help to take their technologies a step further by closing the gap between the laboratory and real life settings, sometimes called "out there in the wild" as some robotic engineers sometimes call this world where people interact with their result.

Some of these findings can be generalized to health care professionals beyond nurses while other findings are specifically relevant for nurses and for the caring situation. Being close to the patient, following in detail the patient's caring needs provides a processual understanding of the development and a deeper sense of tacit knowledge compared to temporary consultations or surgeries.

How to teach technology in nursing is a comprehensive question, not least educational. This discussion is taken place within the teachers group, appointed to be responsible for teaching aspects of technology. The second case on joint learning activities is based on two pedagogic ideas: not starting with change but first understanding what is already in motion (engineers and nurses side by side in a caring situation), and second, present ideas that are a truer expression of what kind of knowledge these two groups need to be prepared for. Since technology is always in progress finding ways to collaborate and communicate independent of what kind of technological changes be considered to be more sustainable than inventing the wheel for every new innovation.

Even though the joint learning activities show promising result, to plan for this becoming a permanent part of nursing and engineering education programs is not without difficulties. These education programs are organized based on deeply rooted perceptions of what nurses and engineers need to learn. Changes in curriculum require clear initiatives and can conflict with both space and focus.

Beside learning activities in bachelor education the KTH-SRCUC program also include PhD training and research cooperation, not least joint seminars. One suggestion leading the attempts to find joint research questions is to meet within non-invested areas. A non-invested area is defined as a context or an intellectual discourse where none of the collaborators has invested interests. At least it can be expected to decrease the level of conflicts that can occur in between paradigms. One way of creating a non-invested area is when groups meet that have not met before as in the second case presented above. Another option is to create spaces for collaboration with care providers outside the education or research department. To fill these spaces with a content, depend on the needs and demands of the care providers and requires a thorough completion of initial dialogue currently underway.

These two cases presented in this paper are selected out of several attempts to create the KTH-SRCUC program. The strengths of the cases are their unique approach of deepening the understanding of what makes collaboration possible or not possible. It opens windows for new ideas and innovations. The weakness of the first case is that the analysis is made after the completion of the project, not planned on beforehand, which could have included a more systematic collection of different kind of information data. In the second case evaluations were conducted but not yet published in detail. In this paper we draw conclusions in accordance to the aim at deepening the knowledge on collaborations between nursing and engineering by taking on a new perspective pointing out the factors leading to successful interactions and collaboration and what are the missing links.

IV. Conclusions

Collaboration between nursing and engineering has long been requested. This initiative suggests that it takes more than just adding two and two together. There is a need for renewed views on what drives technical development in care and how it can be adapted in a socio-technical system. From previous experiences we learn that preparations for collaboration must include the awareness of epistemological differences as well as common interests to critically examine the understanding of how caring practices are constructed and implemented. For nurses to be proactive requires knowledge about technological developments and the ability to collaborate with engineers and participate in design and innovation processes both for healthcare professionals and concerned citizens. For engineers a more thorough understanding of caring situations and users will contribute to a more reliable provision of developed solutions and point at new ideas leading up to innovations.

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