Spring 4-10-2019

Designing from the Inside Out: A Case Study of the Development of an IoT Application

Nancy Russo
Malmö University, nancy.russo@mah.se

Dimitrios Gkouskos
Malmo University, dgkouskos@gmail.com

DESIGNING FROM THE INSIDE OUT: A CASE STUDY OF THE DEVELOPMENT OF AN IOT APPLICATION

Nancy L Russo and Dimitrios Gkouskos
Internet of Things and People Research Center, Department of Computer Science and Media Technology, Malmö University
Email: nancy.russo@mau.se, dgkouskos@gmail.com

Abstract

Far-reaching claims have been made about the potential for the Internet of Things (IOT) to impact a broad range of industries, from manufacturing to healthcare. However, research and development has tended to focus on what the technology can do and not what users want or need. Here we present a case study of the creation and on-going development of a commercially available IOT office solution where the developers and their organization are also users. The development team capitalized on this by bringing together the technology, user experience design and business perspectives in interactive sessions with potential external customers/users to improve the design solution. By actively listening to the potential users and then iteratively adjusting the product and testing continuously via their internal installation, they were able to create a successful commercial product. We believe that these findings can inspire a richer design and development process for future IOT solutions.

Keywords: user roles, user centred design, developers as users

1.0 Introduction

The Internet of Things (IOT), which refers to "objects that are readable, recognizable, locatable, addressable, and controllable via the Internet," (National Intelligence Council, 2008) is often presented as one of the next paradigm-shifting technologies that will change the way we interact with the world and improve our lives in a variety of ways (Porter and Heppelmann, 2014). However, successful commercialization has not been widespread and IOT adoption has not yet lived up to the hype (Seungjun and Hyojung, 2016). IOT products have been criticized for lacking connection to real-world problems, a characteristic that can be attributed to having technological possibility rather than people's needs as a starting point. Designing these systems of objects (sensors, devices, etc.), data, networks and people requires a different approach than those used for designing specific products or artefacts (Ghajargar et al., 2018). Developing an understanding of the target users, their needs, problems, wishes and contexts is therefore a crucial component for designing successful IOT products and services. Gaining successful user

involvement requires not only finding a means to include the appropriate users in design, but also providing users with the necessary space and tools to express their needs while also staying focused on the target problem within the context of the goals of the development organization. This can be challenging, especially in real-world IOT projects where, in many cases, technology is novel and therefore an unknown for the user.

As Markus and Mao (2004) have discussed, traditional IS theories of user participation were developed in a very different development landscape, and did not address trends in IS development such as package integration and outsourced development. In addition, traditional approaches to user participation did not adequately account for software developed for an external, global customer base or for iterative, on-going development processes in conjunction with the user. To better address these contexts, design theory and development practices have been shifting from passive user participation to active user involvement in iterative design and development processes.

In this case study we present a context with an evolving enactment of the user role wherein the application was initially developed by a software engineer as a side project simply to address a problem expressed by a fellow engineer (and also to allow testing of a new technology). Others in the organization saw value in the app and its use spread by word of mouth. Then, as the application morphed into a commercial product, the entire development team, which included not only the software engineer but also a UX designer and product manager with a sales and marketing focus, interacted together with potential corporate clients (customers/users). This joint approach to interacting with the user/customer to determine functional and interface requirements has not been addressed widely in IS or design research. Further, we found that there are several benefits to having members of the development team of an IOT technology be a part of the targeted user group. These were: a head-start on user involvement, a deep collaboration between stakeholders in the team, an ability to listen and understand user problems rather than focusing on selling solutions, and continuous iterative testing and development of the technical solution. These benefits can be used in other IOT development processes to enhance the design and development process with deep, rich, and meaningful user involvement.

In the next section we provide an overview of various stakeholder involvement approaches over time that have been described in the design and IS development literature, with a focus on the user and their interactions with the development team. This is followed by a description of the research method, the case study organization and the software development process that is the focus of this case study. The paper concludes with the findings from the case study and a discussion of how these can be relevant to other organizations.

2.0 Background

Historically our prescriptive development approaches have assumed that most software development is done by large organizations using an in-house development staff to create software that will be used internally. Through the 1980's and into the 1990's, systems were often developed and implemented on a very local basis, within one organization or even one department (Markus and Mao, 2004). But it is more likely today that a software development team is working on software that will be used by external users. Today, we see more focus on iterative development, where a software product is introduced with minimum functionality and then adapts over time in response to user experiences. With user-facing software, the design of the user experience has come to dominate pure functionality, making it even more important to truly understand the user perspective (Gkouskos, 2016).

The role of the user (or customer) in software development has been studied from many different perspectives, however we have not found any published work where the designers and developers were part of the user group during the conception of the technical solution. In this paper we highlight a context in which the users of a particular software application were originally the developer and his colleagues, but over time the application became a commercial product and "the user" label grew to include corporate clients and their employees. To understand how this differs from the role of the user and other stakeholders in the majority of popular information systems development methods, and why it is relevant, it is useful to examine established design and development approaches in terms of the roles of different stakeholders.

2.1 Roles of the User

We use the term "user" to refer to the individuals who are currently using the software or potentially could in the future, as well as those who make decisions about its purchase, such as a business leader acquiring the software for an organization's employees (Eason, 2005).

Even early system development methods acknowledged that user involvement in software development was important, but early approaches to user involvement have been quite passive (Beath & Orlikowski, 1994). Traditional approaches typically follow a waterfall model that prescribes a series of sequential steps for software development, involving the user/customer in a limited "formal" way in only certain specific steps of the development process (Royce, 1970). Users are assumed to provide input (usually via interview or survey) into the analysis of the problem context and the identification of desired functionality, and possibly to perform some acceptance testing when the software is completed.

Agile development methods advocate increased user involvement in the process by having a user representative co-located as a member of the development team (Abrahamsson, 2002). Users, through their representative, are supposed to provide both requirements (through user stories) and test cases, and to be available to provide additional details to the development team when needed. Both Action Research (Avison et al., 1999) and Design Science (Hevner et al., 2004) research approaches could be considered as focusing on the user's needs when defining the problem or issue to address with the system development process and when evaluating the results. However, the actual user involvement levels vary across projects, and the focus may be more on organizational goals than individual user needs and preferences.

When users are not readily available to be interviewed, surveyed, or to join the development team, fictitious users termed personas may be created to represent the user. One or more personas may be created to represent the user population, with the defining characteristics often based on research (Ma and LeRouge, 2007).

User centered design (UCD) can be considered a major shift in the design of interactive systems as it places the user at the center of the design process. In a UCD process users are involved as study subjects at the start of the design process and in usability evaluations of prototypes. UCD has been evolving through an increase in the importance placed on user involvement in the design process. UCD strives to

capture the users' needs and engage users in the design process in an integral, iterative way (Abras et al, 2004). The way user-centeredness is implemented can vary from users as active participants to users represented by proxies such UX designers, personas, representatives, or work roles (Iivari & Iivari, 2011).

With an increasing focus on user experience (UX), UCD processes have evolved into experience centered design. In such a design process the user's experience is at the center of attention and factors such as context, emotion and time are significant in the shaping of the design artifact (Hassenzahl, 2010). In UX design processes, users are often involved through contextualized qualitative research such as interviewing, workshops and other ethnographically inspired methods. (Roto et al., 2011; Gray, 2016).

Another strand of design is participatory design. In this type of design process the user is meant to actively participate in the making of the design artefact. In a participatory process the roles of users, designers and other stakeholders are blurred in order to re- distribute power and responsibility among stakeholders and thus increase user involvement through participation (Kensing & Blomberg 1998; Sanders & Stappers, 2008). Participatory design approaches have recognized the importance of truly understanding the users and their context, which requires designers and developers to take a more ethnographic approach, in some cases working alongside the ultimate users of the system. This type of approach not only enables the designers and developers to gain empathy for the users, but it also enables the users to become much more active in the development process. This leads to situations where the users become co-developers, not only suggesting and requesting system features and evaluating prototypes, but potentially driving the process.

The tradition of participatory design has a lot to offer to the development of IOT technologies, especially concerning user involvement. Reddy and Linde (2016) argue that involving users as active participants in the prototyping of IOT solutions is crucial to developing an understanding that can enable building technology to address rich and diverse user needs.

There has been some relevant research work on how IOT technologies can be developed with user participation in different settings. One example is a study of IOT development in a participatory way by Fischer and Crabtree (2016), in order to provide energy consumption advice in a home setting. For this study, the authors

adopted a participatory design perspective where all of the stakeholders, including users, took part in the research activities, and the research took place in the homes of the users. Another study utilized the Do it Yourself approach to involve users in the making of IOT technology. In this study by Woo and Lim (2015) users themselves were given the opportunity to custom build IOT solutions and thus decide on the user experience that they would like to have within the limitations of the D.I.Y kits that were used. These examples illustrate the potential value of deeply involving users in the design of IOT technology, but that focus has not been well represented in IOT development literature.

While active user participation in the design and development process is important, other stakeholders have an impact on the development process as well.

2.2 Roles of the Technical Team

We will use the term "software engineer" to refer to those who are writing and deploying the code, and "UX designer" to refer to those who are designing and implementing the user interface. Other technical members of the development team could be project managers, platform developers, testers, or networking or data experts, for example.

One of the more prominent attributes of a successful UX designer is the ability to empathize with the user (or potential user) to facilitate understanding for the user's circumstance, needs and wishes by bridging the gap between users and designers. The importance of empathy is highlighted in much of the design research published around user involvement in design (Chapman, 2012; Kouprie & Visser, 2009; Mattelmaki & Battarbee, 2002).

While it may seem more obvious that it is the role of the UX designer to facilitate the participation of the user, the developer or software engineer also plays a role "in creating …opportunities for users to participate" (Markus and Mao, 2004, p. 519). This participation is more important than its contribution to requirement elicitation. The development of relationships between the development team and the users contributes not only to a process that is more satisfying to both groups, but also results in socio-technical solutions that more fully meet the users' needs (Markus and Mao, 2004).

The interactions between the technical team and the users varies across different types of projects with different levels of user participation (Keil and Carmel, 1995). At one extreme, it is possible for individuals to be both in the technology team (designers, software engineers) and in the target user group.

2.3 Roles of the Business Side, Particularly Sales and Marketing

Our investigation of the software design and development literature did not uncover any formal design or development approaches that describe a specific role for business functions such as sales and marketing, although these are routinely mentioned in new product development literature (e.g., Moenaert and Souder, 1990). Ebert and Brinkkemper (2014) do, however, adapt a product development model to software development, highlighting the importance of mapping requirements to value creation. They identify the role of "product manager" who manages the product throughout its life cycle "with the objective of generating the biggest possible value to the business" (p. 17)

The case study described below provided an opportunity to explore how these roles were enacted in the development process under study to address our broad research goal of understanding how this application was designed and developed, and what can we learn from it.

3.0 Method

The findings reported here are part of a larger case study of the development, deployment and impact of a commercial IOT office solution product.

Data for this portion of the study was collected via semi-structured interviews (Beyer & Holtzblatt, 1997) with participants in the design, development and deployment process. Two UX designers (identified as UX1 and UX2), one software engineer (SE), two high-level managers (identified as GM1 and GM2), and two facility managers (FM1 and FM2) were interviewed. The interviewees were selected due to their key roles in shaping both the IOT application and also in defining the inside-out approach that we describe here. An interview script was created for each type of interviewee. (Available from the authors upon request.) Interviews lasted between 45 and 60 minutes. In addition, the researchers participated in several meetings to discuss the software and to understand the broader organizational environment. The

researchers also spent some time at the research site as “pseudo-employees” so that they could have personal experience using the software.

The transcribed interview data was analysed using qualitative semantic analysis (Miles & Huberman, 2014) where the researchers labelled and categorized snippets of the transcribed interview data into categories of similar meaning in an iterative way. Researchers identified relevant themes from the transcripts, discussed in the findings section.

The final phase of the study will collect data from end-users (both current users and potential users) of the application to explore how the application is used (which features and how frequently), the benefits the users derive from the application, reasons for not using the application, desired additional features, as well as individual, task and workstyle characteristics.

4.0 Case Study

This case study of the evolution of a software application from an in-house side project to a commercial product highlights the characteristics of the development context that we believe contributed to the success of the product. Key findings identify activities and processes that can be adapted by other organizations to suit their own specific contexts.

The case study site was the European division of a multi-national corporation which we will refer to here as EMNC. This division has primarily developed hardware and software, including consumer applications. The software that is the focus of our study is an IOT-based office solution/application that uses indoor positioning through hardware sensors to enable users to avoid time-wasting searching for meeting rooms and locating colleagues. The software allows users to view a facility map, their own location, and the location of workspaces on smartphones as a downloadable app and on large monitors located throughout the facility. Via the smartphone app, users can also search for co-workers and available meeting rooms, which is particularly important in open plan activity-based workplaces. The smartphone app notifies users when it is time to leave for a meeting in the facility and allows booking of rooms. In addition, sensors provide data on space utilization. The product is enriched with additional features on an on-going basis.

The IOT solution was initially developed in 2009-2010 as a personal project by a software engineer to solve a very local problem: it was difficult and time consuming to locate meeting rooms in their buildings, and by creating the meeting room locating app the software engineer could both solve this problem and test the effectiveness of indoor positioning technologies under development.

> *"One of the main reasons to work on this platform was to evaluate different indoors positioning technologies. It started as an experiment. We did it on 10% time. It was a pet project, not official work."- SE*

Use of the IOT solution spread gradually by word-of-mouth through the host organization. Initially the only way to get the application was to obtain a copy from the developers but eventually the application was made available on to all EMNC employees via an online application store.

In 2015, changes in the competitive environment drove the organization to change its business model from being primarily a hardware vendor with software and applications supporting that hardware to a focus on new applications and related products. The organization began actively seeking innovations that would both effectively utilize in-house skills and achieve commercial success.

Whereas the typical approach to this type of drive for innovation is to look outside the organization for problems that need to be solved, in this case the problem and solution were identified internally. The "a-ha moment" was to recognize that this local problem was one also faced by other organizations.

> *"We got a lot of feedback from others. People that left [the company] and went elsewhere came back to us and said they needed this technology for their offices too." – SE*

However, there were hurdles to overcome. The application had been developed by software engineers for their own use and while it was functional, it didn't have an attractive appearance nor was it easy to use. User experience (UX) designers were brought in to create a better interface. Expertise was also needed to identify the external market and to transition this software from a tool to a product. A manager with sales and marketing skills joined the team as a product manager.

Meetings were held with facilities management at several large companies both to understand the contexts of those organizations and to determine what features of the office solutions application could provide value to those organizations. The meetings were attended by the product team consisting of the product manager, a

UX designer, and a software engineer. From these meetings the team identified a core set of functions that would address the problems that were common across the organizations.

To prepare the first iteration of the office solutions application for commercialization, some functionality was removed because it was too localized to EMNC's environment, too difficult to implement in other contexts, or not identified as useful by the potential customers. The user interface was modified and processes and tools were created to facilitate the installation of the product. As each change was made to the application, it was reflected in the application used by EMNC employees and thus tested in a live installation. A pilot installation at two customer sites was initiated in 2016. The application entered the commercial market in 2017 and sales have been steady. The product team continues to meet with existing and potential customers to identify new features to add.

5.0 Findings

Based on our analysis of the design and development process, we have grouped the relevant findings in four themes that highlight the particular aspects of the approach that contributed to its success.

5.1 A Head-Start on User Involvement: Designing from the Inside

Coming up with an idea to solve one's own problem can have some clear benefits. The initial team has been quite invested in the idea that they had, and clearly understand the context from a user perspective. Rather than conducting ethnographic research with potential users, the initial developers engaged in "auto-ethnography" by being users of the application they were creating. One of the difficulties in early design and development processes can be having access to the user group. In the case where designers are part of the user group this issue is resolved.

The challenge when working from this internally-initiated perspective is to broaden the understanding of the problem by including experiences and perspectives of other potential users. As the design team in our case study grew and progressed,

new perspectives were added to the mix, both from internal company employees but also from external users. This enabled the developers to realize that different users appreciated different aspects of the product. One example is the use of bubbles containing the user's photo and name which display on the local large monitor (TV screen) when the user approaches a that monitor.

> *"We get feedback that people like the TV screen bubbles popping up. I don't see the value in that. We had a lot of positive feedback on the bubbles that they make something dynamic and personalized and that is valued by the customers" – SE*

5.2 Co-developing: Users + Technology, Design and Business Perspectives

One of the effects of having a small development team where developers belong to the user group was that the design, the business idea and the necessary technology were developed simultaneously. This type of work allowed the team greater flexibility as they could quickly adapt different parts of the product package based on business, technology and design needs. Having a close collaboration between product team members and including the software engineer, the UX designer and the product manager in meetings with potential customer organizations provided significant benefits. As one UX designer stated:

> *[This was] "more than a user-centered approach. From a designer's perspective this is the best data I've ever had [because] I got the business version of it too, I knew why they want to pay us money for it." - UX1*

As it turned out, having a multi-disciplinary team partake in client meetings led to better deciphering of the client's needs by using each stakeholder's own expertise; a technology expert could easily see opportunities to use technology to satisfy the clients' needs, a designer could readily identify UX needs, and the business expert could ensure the product is viable in the market. The business leadership also recognized the value in this approach.

> *"Engineers they do stuff because they can, they do things that are brilliant from an engineering perspective, but they don't think ahead. Who is going to. buy it, how can we price it? That is the part we need to add to the equation now. A combination of these competencies will be the key to success." - GM1*

5.3 Listening to Problems Rather than Selling Pre-made Solutions

Another characteristic present in this case study was that meetings with prospective clients were more focused on listening to the client and adapting the solution based on expressed needs rather than on selling the product to the client. This practice provided valuable feedback to the product team to enable them to improve the design and functionality of the product based on client's expressed needs. The fact that the product team themselves belong to the user group enables greater empathy and a deeper understanding of end users and clients.

> *"We quickly had interested customers and a prioritisation of what the important problems were. We saw the same issues come up in these companies." - UX1*

As the business leaders pointed out, this was EMNC's first experience selling in the business-to-business (B2B) space rather than business-to-consumer (B2C), and "selling IOT [such as this product] is different." (GM2) The process of listening to the problems of other organizations both created relationships with potential customers and allowed a more streamlined development process because time was not wasted on features that were not relevant.

5.4 Continuous Testing: The Lived Experience

Since EMNC employees had been using the software through various iterations since 2010, the product was in effect being continuously tested. The lived experience of the product gave valuable insights that simply would not have been possible by testing done externally.

> *"[The application] was developed from [engineers] but they developed it for themselves as users. They used our facilities as a test bench, and we facility managers we support that." – FM2*

Even after the commercialization of the product, new designs, new sensors, and new features were tested at EMNC before rolling them out to customers.

> *"We still have [the developing organization] as a test house and then we can do what we want. If I were a customer it would be valuable to me to know that the company that makes the product use it themselves" - SE*

A challenge was to ensure that internal testing was done not just by the developers but also by users not involved in the project.

> *"How do you get people using it for the first time so they get hooked on it? One of the key challenges: how do you get people to actually test things?*

There are always people who are really into technology - they will test everything. But then the challenge is when you scale it, how do you do that, how do you get people to like it?" - GM1

In addition, the development team worked closely with the pilot companies, gathering feedback at multiple points in time.

"Pilot companies would pay in interview hours, so we interviewed before installation, after one month of use and then later on. And we had the statistics as well" – UX1

6.0 Discussion and Conclusions

In the case study presented here, the product development team members were also users of the product. We found that the dual roles of the product team resulted in some clear benefits that could be seen in the design and development process. While the engineers' technical and local knowledge were essential for the initial creation of the application, feedback from other users was necessary to create a better product. Early and on-going user involvement, an openness to users and their needs, and a synergistic collaboration between business, technology and design ultimately produced a commercially successful product.

The fact that the initial version of the product was created internally was beneficial because both a deep understanding of the problem and the technical knowledge to solve it existed in-house. This type of "sticky" knowledge, as Von Hippel (1994) calls it, can be expensive and difficult to acquire if not available in the organization. However, whenever a developer is creating an application from first-hand experience there is the risk that the developer's experience may be significantly different from that of a typical user. Here the interdisciplinary nature of the product team along with early involvement of other users both at EMNC and the pilot companies in the design process allowed for developing a broader understanding of the problems faced by a variety of organizations and individuals. The creation of a cross-functional team bridging both technology (UX design and software engineering) and business sales and marketing knowledge was important in this case. This is consistent with new product development studies that indicate that cross-functional teams are critical (e.g., Ernst et al., 2010).

The problem-solving approach taken by this team when meeting with potential customers also contributed to success. This is consistent with what Markus and Mao (2004) found, "When change agents use a "facilitation" approach rather than a "technical expert" approach to participation, participation in solution development is more likely to contribute positively to both system quality and solution implementation".

Often in development projects limited attention is given to how the system or software is integrated into the actual work environment and how feedback from its use can influence on-going design efforts (Hartswood et al., 2000; Berg, 1999). However, in this case feedback was obtained throughout the product lifecycle both inside the development organization and from external users. This lived experience of using the application provided valuable feedback that was used to improve the product.

While not every software development organization will be able to identify a home- grown application that can become a commercial product, most should be able to apply some of the other approaches used by EMNC. While these insights are not necessarily unique to IOT, they are particularly relevant in environments where technology is new or rapidly evolving, which makes it more difficult to determine up front how the technology can meets the needs of users.

There are some additional limitations that should be taken into account. This study was conducted in only one organization and regarding the development process for one IOT-based product. No end users in client companies were included in this part of the study, and the product has not been in the market for an extended period of time.

Acknowledgement

This work was partially financed by the Knowledge Foundation through the Internet of Things and People research profile.

References

Abrahamsson, P., Salo, O., Ronkainen, J. and Warsta, J. (2002) Agile software development methods: Review and analysis, VTT publication 478, Espoo, Finland.

Abras, C., Maloney-Krichmar, D., and Preece, J. (2004) *User-centered design*. In W. Bainbridge (Ed.), Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications.

Avison, D.E., Lau, F., Myers, M., and Nielsen, PA (1999) *Making academic research more relevant*. Communications of the ACM, 42(1) 94-97.

Beath, C.M., and Orlikowski, W. J. (1994) *The Contradictory Structure of Systems Development Methodologies: Deconstructing the IS-User Relationship in Information Engineering*. Information Systems Research, 5(4) 350-377.

Beyer, H., and Holtzblatt, K. (1997) Contextual Design: Defining Customer-Centered Systems. Elsevier Science.

Chapman, J. (2012) Emotionally durable design: Objects, experiences and empathy. Routledge.

Crowne, M. (2002) *Why software product startups fail and what to do about it.* In: Proceedings International Engineering Management Conference (IEMC), pp. 338– 343.

Eason, K. D. (2005) Information technology and organisational change. CRC Press.

Ebert, C., and Brinkkemper, S. (2014) *Software product management–An industry evaluation*. Journal of Systems and Software, 95, 10-18.

Ernst, H., Hoyer, W. D., and Rübsaamen, C. (2010) *Sales, Marketing, and Research-and-Development Cooperation Across New Product Development Stages: Implications for Success*. Journal of Marketing, 74(5), 80–92. https://doi.org/10.1509/jmkg.74.5.80

Fischer, J. E., Crabtree, A., Rodden, T., Colley, J. A., Costanza, E., Jewell, M. O., and Ramchurn, S. D. (2016) *Just whack it on until it gets hot.* In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '16 (pp. 5933–5944).

Ghajargar, M., Wiberg, M., & Stolterman, E. (2018) *Designing IOT systems that support reflective thinking: A relational approach*. International Journal of Design, 12(1) 21-35.

Gkouskos, D. (2016) User Experience Insight: Steering Experience Design Through Meaningful Incorporation. Chalmers University of Technology.

Hartswood, M., Procter, R., Rouncefield, M. and Sharpe, M. (2000) *Being there and doing IT: A case study of a co-development approach in healthcare*. In: 6th Biennial Participatory Design Conference, New York, 28 Nov-1 Dec 2000. Published in: PDC 2000: Proceedings of the participatory design conference, pp. 96-105.

Hassenzahl, M. (2010) *Experience Design: Technology for All the Right Reasons*. Synthesis Lectures on Human-Centered Informatics, 3(1) 1–95.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004) *Design science in information systems research*. MIS quarterly, 28(1) 75-105.

Iivari, J., and Iivari, N. (2011) *Varieties of user-centeredness: An analysis of four systems development methods*. Information Systems Journal, 21(2), 125-153.

Ives, B., Palese, B., and Rodriguez, J. A. (2016) *Enhancing Customer Service through the Internet of Things and Digital Data Streams.* MIS Quarterly Executive, 15(4).

Keil, M., and Carmel, E. (1995) *Customer-Developer Links in Software Development*. Communications of the ACM, 38(5) 33–44. https://doi.org/10.1145/203356.203363

Kensing, F., and Blomberg, J. (1998) *Participatory design: Issues and concerns*. Computer Supported Cooperative Work (CSCW), (1993), 167–185.

Kouprie, M., and Visser, F. S. (2009) *A framework for empathy in design: Stepping into and out of the user's life.* Journal of Engineering Design, 20(5), 437–448.

Ma, J., and LeRouge, C. (2007) *Introducing user profiles and personas into information systems development*. AMCIS 2007 Proceedings, 237.

Markus, M.L. and Mao, Y. (2004) *Participation in development and implementation – updating an old, tired concept for today's IS contexts*. Journal of the Association for Information Systems, 5, 514–544.

Miles, M. B., and Huberman, A. M. (2014) Qualitative data analysis: An expanded sourcebook (3d ed.). Thousand Oaks, CA: Sage Publications. (p 165).

Moenaert, R. K., and Souder, W. E. (1990) *An information transfer model for integrating marketing and R&D personnel in new product development projects*. Journal of Product Innovation Management, 7(2) 91-107.

National Intelligence Council (2008) Disruptive Technologies Global Trends 2025: Six Technologies with Potential Impacts on US Interests out to 2025. Available online: http://www.fas.org.irp/nic/disruptive.pdf (accessed 12 October 2018).

Porter M.E. and Heppelmann, J.E. (2014) *How smart, connected products are transforming competition*. Harvard Business Review 92:11–64.

Reddy, A., and Linde, P. (2016) *The Role of Participation in Designing for IOT*. In DRS 2016 (pp. 1–13). Brighton, UK: Proceedings of DRS 2016.

Royce, D. W. W. (1970) *Managing the Development of large Software Systems*. IEEE Wescon, (August), 1–9.

Sanders, E. B.-N., and Stappers, P. J. (2008) *Co-creation and the new landscapes of design*. CoDesign, 4(1) 5–18.

Seungjun, Y. and Hyojung, J., (2016) *Issues and Implementation Strategies of the IOT (Internet of Things) Industry*. In Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2016 10th International Conference on (pp. 503-508). IEEE.

Visser, F. S., Stappers, P. J., van der Lugt, R., and Sanders, E. B.-N. (2005) *Contextmapping: experiences from practice*. CoDesign, 1(2), 119-149.

Von Hippel, E. (1994) *"Sticky Information" and the Locus of Problem Solving: Implications for Innovation*. Management Science, 40(4) 429–439. https://doi.org/doi: DOI: 10.1016/0165-1889(95)00925-6

Woo, J., and Lim, Y. (2015) *User Experience in Do-It-Yourself-Style Smart Homes*. Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing - UbiComp '15, 779–790.