The effect of contextual aspects on importance ratings of usability dimensions in system evaluation

HANS JANDER, JONATHAN BORGVALL,
HENRIK ARTMAN, ROBERT RAMBERG

FOI-R--4397--SE
ISSN 1650-1942 December 2016

Hans Jander, Jonathan Borgvall, Henrik Artman, Robert Ramberg

The effect of contextual aspects on importance ratings of usability dimensions in system evaluation

Titel	Effekten av kontextuella aspekter vid värdering av användbarhetsdimensioner i systemutvärdering
Title	The effect of contextual aspects on importance ratings of usability dimensions in system evaluation
Rapportnr/Report no	FOI-R--4397--SE
Månad/Month	December
Utgivningsår/Year	2016
Antal sidor/Pages	21
ISSN	1650-1942
Kund/Customer	Försvarsmakten/Swedish Armed Forces
Forskningsområde	3. Flygteknik och luftstridssimulering
FoT-område	Ledning och MSI
Projektnr/Project no	E60815
Godkänd av/Approved by	Stefan Ungerth
Ansvarig avdelning	Försvars- och säkerhetssystem

Sammanfattning

Kontextuella aspekter av interaktion bör övervägas vid utveckling och utvärdering av olika typer av system. Denna studie undersöker betydelsen av kontextuella aspekter för fem användbarhetsdimensioner i systemutveckling och utvärdering: relevans, effektivitet, lärbarhet, felhantering och attityd/inställning. Två olika kontextuella aspekter av användning undersöktes under system-utvärderingstest där två grupper av erfarna stridspiloter utförde fördefinierade uppgifter i ett nytt system för civil navigering och ett nytt system för angivning av mål. Resultaten från systemutvärderingstesten tyder på att kontextuella aspekter har effekt på användarens skattningar av betydelse för alla dimensioner, och att de kontextuella aspekterna bedömdes av användarna som viktigare i samband med angivning av mål. En slutsats blir att kontexten har avgörande betydelse vid bedömning av relevansen hos användbarhetsmått. Detta innebär att föreslaget ramverk bidrar till systemutveckling och utvärdering av simulerade och scenariobaserade miljöer och pekar vidare på vikten av designen av scenarier för genomförande av utvärderingar av användbarhet i simulerade miljöer.

Nyckelord: användbarhet, HMI, HCI, systemutvärdering, användbarhetsutvärdering, kontextuella aspekter av utvärdering, användningskontext, dimensioner av användbarhet

Summary

Contextual aspects of interaction should be considered during system development and evaluation. This study investigates the importance of contextual aspects for five usability dimensions in system development and evaluation: Relevance, Efficiency, Learnability, Error Management, and Attitudes. Two different contextual aspects of use were investigated during system evaluation testing, where two groups of experienced fighter pilots performed predefined tasks in a new system for civil navigation, and a new system for target designation. The results from the system evaluation testing indicate that contextual aspects have an effect on user importance ratings across all dimensions and they were rated as more important in the context of target designation. Thus, the context has settling importance when assessing the relevance of usability measures. This implies that the framework contributes to systems development and evaluation in simulated scenario-based environments and further point to the importance of staying sensitive to the design of scenarios when conducting usability evaluations in simulated environments.

Keywords: usability, HMI, HCI, system evaluation, usability evaluation, contextual aspects of evaluation, context of use, dimensions of usability

Table of contents

1 Introduction

In the human-centered system design process for interactive systems (Hackos & Redish, 1998; ISO 9241-210, 2010) the evaluation phase forms a hub throughout the iterative process. Evaluations are in many cases not prioritized to a sufficient extent, especially in situations when project budgets and time constraints run short. Sometimes evaluations are not conducted at all. In some cases evaluations are conducted but not in an appropriate way due to a feeble methods that tend to confirm what is already working well without revealing where the critical design issues are (Woolrych & Cockton, 2001; Artman & Zäll, 2005; Markensten & Artman, 2004). Today a variety of methods and techniques for development and design of human-computer interaction (HCI) and usability evaluations exist. Some methods are very resource demanding and time consuming, and for those reasons some methods do not even involve end users. The results from evaluations strongly depend on the method and the context, and consequently this has an effect on the validity of the results. The complexity of the domain that is approached further adds to the challenge of conducting valid and reliable evaluations. There is a growing body of mixed-methods research acknowledging this problem by emphasizing the importance of matching research problems with appropriate research design (Burke Johnson & Onwuegbuzie, 2004; Cresswell & Clark, 2011). Instead of being stuck in a quantitative or a qualitative research paradigm, mixed-methods research assumes a pragmatic approach utilizing the strengths of both paradigms in research design, data collection, and analysis (Thassakori & Teddlie, 2003). Mixed-methods research – a form of triangulation of methodologies for data collection and analysis – have been emphasized for instance within the field of software engineering (Runeson & Höst, 2008), in multi-media research to understand evaluation criteria of quality (Strohmeier, Jumisko-Pykkö & Kunze, 2010), and in aviation simulation and training research (Mayberry, Jaszlics, Stottlemyer & Fritz, 2012; Svensson, Angelborg-Thanderz, Borgvall, & Castor, 2013).

When developing and designing for HCI, human-machine interaction (HMI), and usability the context of use for a system is of great importance and must be carefully considered (Hackos & Redish, 1998). In ISO DIS 9241-11 (1998) usability is defined as *"the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use"*. The consideration of the context of use is also articulated in Hackos & Redish (1998) iterative description of the design process lifecycle. The contextual turn in the social sciences and particularly within HCI has emphasized and pointed at the importance of "contextuality" and "situatedness" of use (Suchman, 2007). A rhetorical question that can be formulated given this focus is whether system development projects should conduct as many evaluations as there are possible contexts and situations of use? Even the most moderate system with its functionality may be used in different ways and in different situations.

The work presented in this paper is an attempt to systematically investigate to what extent contexts of use in terms of scenarios and tasks in the domain of HMI evaluation for high-risk and task-critical environments has an effect on the outcome of such evaluations.

Usability testing and evaluation is an empirical method for eliciting and identifying strengths and weaknesses in the usability of a product or a system. It has the characteristics of using participants that are end users to perform tasks with the product or system. Usability evaluation should typically be conducted iteratively throughout the product/system development process. Cost-effectiveness is reached if changes in design can be performed early, which also has an effect on the influence of considerations that need to be made to design a proficient system (Hackos & Redish, 1998; Dumas & Salzman, 2006; Benyon, 2010).

Traditionally, Human Factors (HF) evaluation methods are more concerned with measuring quantitative aspects of interaction (e.g. error frequency, accuracy, speed, time). Traditional HF is also more concerned with the physical workspace. HCI and usability methods add dimensions such as measurement of efficiency, effectiveness, attitudes, relevance, and emotions, and are also to a higher degree concerned with qualitative aspects of interaction (Carroll, 2001 & 2003; Harper, Rodden, Rogers, and Sellen, 2008).

Regardless of the particular methodological approach (traditional HF, HCI, or usability), the context of use for a system is crucial during system evaluations (Benyon, 2010; Suchman, 2007). It is for obvious reasons not enough to put anyone as an operator when testing and evaluating a new system. Further, involving potential end users during testing and evaluation of a new system is not enough - if the context of use is not explicitly presented. Traditionally, human factors and ergonomics have focused on the interaction between the operator and the machine, e.g. what the instruments should look like and how the controls should be designed (Hollnagel & Woods, 2005). However, the context in which the interaction between the operator and the system occurs must be emphasized during evaluation and in the interpretation of the result from such evaluations (Benyon, 2010).

There are some ambiguities about how to define a system that is to be evaluated. Systems are designed for a purpose and should help a person or another system to perform a set of tasks, often under uncertain and non-permissive conditions. However, the system does not merely consist of an operator and an interface. Hollnagel & Woods (2005) describe theories of joint cognitive systems (JCS) by giving an example of driving a car. The lowest level of the JCS is the car and the operator. Higher levels of this example of a JCS also include roads, traffic infra-structure, topography, and weather. Similar to the theories of JCS, where the higher level of system characteristics should be considered and emphasized when defining a system, contextual aspects (e.g. domain, task, user experiences, etc.) should also be carefully attended to when conducting system evaluation.

There exist a large number of possible HMI/usability criteria measures (Nielsen, 1993; Löwgren, 1993; Quesenbery, 2004; Vallstrand, 2009; Shneiderman, 2009; Albers & Still, 2011; Jander, Borgvall, & Ramberg, 2012; Usabilitynet.org, viewed 2011-07-01). HMI and usability criteria can to some extent be considered as general and generic, and thus also be applicable across domains. Surprisingly enough, very few examples of the utilization of usability measures within the domain of high risk and task critical environments were found in the literature.

It would be very convenient to assume that all usability criteria should have equal importance across domains. However, this is most likely not the case. For example a criteria referring to error management probably has a more crucial importance in the context (domain & task) of a fighter pilot performing a task in a combat scenario than in the context of an administrator working with an office program. Different usability criteria may also interact and correlations between various usability criteria are dependent on aspects such as the domain, the user's previous experience, and the context of use (Frokjear, Hertzum, & Hornbaek, 2000).

Quesenbery (2003) describes the usability concept with the "5Es" of usability dimensions (Error tolerant, Effective, Efficient, Engaging, and Easy to learn) and attempts to operationalize the concept and illustrate how the different usability dimensions varies in importance depending on the context and application. Figure 1 shows an example of a museum site and the relative proportions of importance across the "5Es" of usability dimensions.

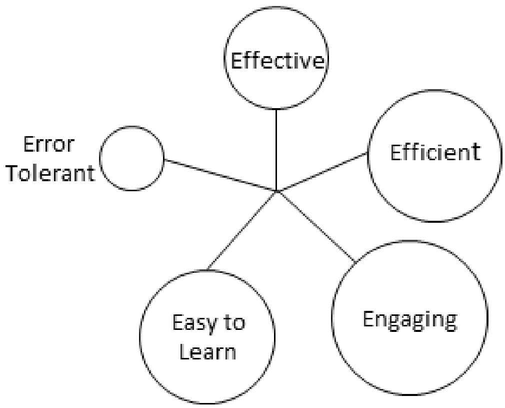

Figure 1. The relative proportions of importance of the 5Es usability dimensions for a museum site. (Adapted from Quesenbery, 2003. In Albers & Mazur [Eds.], 2003).

The relative importance of different usability criteria/dimensions may also differ within domains depending on the context of use. In the fighter pilot example presented earlier, the relative importance of different criteria would most likely vary depending on the task and system used within the domain.

A new methodological framework for HMI evaluation has recently been developed and is described in detail in Jander, Borgvall, Ramberg (2012). Parts of the methodological framework are highly inspired by the research field of usability. The initial purpose of the framework was to develop valid evaluation methods for the domain of high-risk and task-critical environments applicable in a system development process within the industry. Usability methods and measures are not commonly used in the specific domain approached here - HMI in fighter aircraft cockpit development.

The developed evaluation method is scenario-based and potential end users perform relevant tasks with the evaluated system in a simulator. The method was developed for evaluating systems in information intense environments and more specifically evaluation of HMI for fighter aircraft cockpits.

A HMI assessment survey is included in the methodological evaluation framework and consists of 25 HMI/usability sub-criteria formulated as statements, e.g. “Menus, symbols and text are grouped in a logical way”. All sub-criteria are classified and categorized under the five main dimensions: Relevance, Efficiency, Learnability, Error Management, and Attitudes. These five usability dimensions were labeled in a workshop with four HCI SMEs with extensive experience of HCI evaluation methods and techniques. The dimensions were derived through an iterative process consisting of literature reviews in combination with results from interviews with system developers and end users (fighter pilots) involved in system evaluation.

2 Objective

The overall objective of the study reported in this paper was to further evaluate the framework and contribute to more efficient, valid, and agile evaluation methods for systems development. More specifically, the objective was to investigate the effect of context of use in system evaluation within the domain of fighter aircraft cockpit HMI evaluation on the five HMI usability dimensions (Relevance, Efficiency, Learnability, Error Management, and Attitude).

3 Methodological approach

The case study was conducted with experienced fighter pilots, and utilized an exploratory approach to address the research questions under investigation: if, how, and to what extent different usability dimensions relative importance were valued differently by users depending on the context of use during the systems evaluation.

3.1 Participants

Six fighter pilots participated in the study. The age of the participants varied from 29 to 53 years with a mean age of 41 years. The level of working experience ranged from 8 to 35 years with a mean experience of 19 years. All participants were male, and had extensive experience of live (i.e. real platform) and simulated flight training. The group of participants was statistically small but considering the total/limited population of fighter pilots in addition to homogeneity of the group, the results of the study is considered valid to the population of fighter pilots (Castor, 2009; Borgvall, Castor, & Bennett, 2009).

3.2 Equipment

Two flight simulator facilities were used for the study, one tactical team training and research simulation facility at the Swedish Air Force Combat Simulation Centre (FLSC), Swedish Defence Research Agency (FOI), and one test and evaluation simulation facility at Saab Aeronautics in Sweden, mainly designed to test and evaluate new designs in fighter aircraft development. Both facilities provide simulations of the fighter aircraft JAS39 Gripen. The HMI assessment survey (Jander, Borgvall, & Ramberg, 2012) was used to rate the importance of the 25 HMI criteria grouped in the five usability dimensions Relevance, Efficiency, Learnability, Error management, and Attitude[1].

3.3 Procedure

The participants were divided into two groups, each group performing a predefined scenario. Two of the participants performed both scenarios to enable reliability check of ratings of the two different systems and scenarios. The scenarios represented two different contextual conditions including different tasks to

[1]Jander, Borgvall, and Ramberg (2012) includes the survey presented and the evaluation framework is explained in more detail.

perform. Both group performances took place in advanced full-scale simulator environments (see Figure 2).

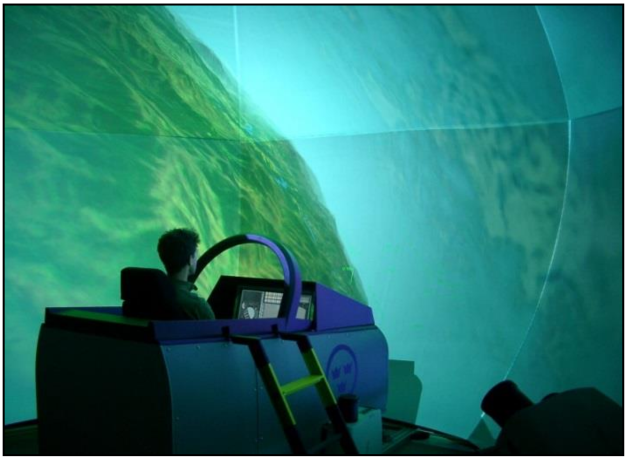

Figure 2. Full-scale simulator environment at FOI/FLSC.

Group 1 (three participants) performed an individual task flying a scenario in a flight simulator using a new system for civil navigation in the simulator at Saab Aeronautics. Group 2 (five participants) performed an individual task flying a scenario in the flight simulator at FLSC using a new system for target designation. Two of the participants in the study were included in both groups due to the low availability of subjects. After each performance in the flight simulator the participants were asked to rate how important each of the 25 HMI criteria was to the particular context of use (civil navigation or target designation). More specifically, the ratings concerned the importance of the fulfillment of the different criteria from a HMI perspective, as experienced by the subjects. The rating scale was a six-point Lickert scale (1 = not important to 6 = very important). Both systems (civil navigation and target designation) were new to the participants and they all received familiarization training before the test session to get acquainted with the system. The training took between five and twenty minutes.

3.4 Analysis

All mean values from the participants' importance ratings were first calculated on group level (Group 1 & 2) for each of the five main HMI dimensions (Relevance, Efficiency, Learnability, Error Management, and Attitude). Furthermore, the two subjects who participated in both scenarios counted as a reliability check of ratings of the two different systems and scenarios. The mean value ratings from these (P1

& P2) were then analyzed separately and comparisons were made on an individual level between the two different contextual conditions (civil navigation and target designation).

4 Results

The results on group level are presented in Table 1 and shows that the contextual aspect of use had an effect on the subjects' importance ratings for the five usability dimensions. All five usability dimensions were rated as more important in the context of target designation. All usability dimensions were rated highly important in the context of target designation. Especially the dimensions of Relevance, Error Management, and Attitude were rated very high. Thus, even in simulation of high-risk scenarios the framework allows discrimination of relative differences in terms of the importance of the usability dimensions. One plausible interpretation is that the risk experienced within a scenario correlates with an increased need for usability. The result is also illustrated in Figure 2 by a spider-web diagram showing a pattern where the importance of the usability dimensions is lower in the context of civil navigation across all five dimensions.

Table 1. The mean value of usability dimensions rating depending of the contextual aspects of use on group level.

Usability dimension	Group 1 (Civil Navigation) n=3	Group 2 (Target Designation) n=5
Relevance	5.67	5.80
Efficiency	5.27	5.52
Learnability	4.94	5.37
Error Management	4.57	5.74
Attitude	5.13	5.76

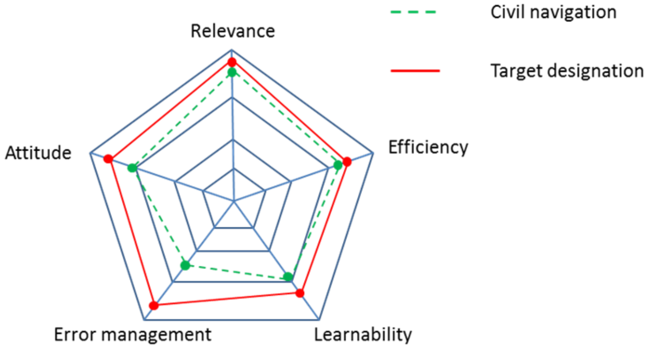

Figure 3. The pattern of the relative area of importance of the usability dimensions depending of the contextual aspects of use.

The results on individual level of the two participants (P1 & P2) included in both groups are described in Table 2 & 3. P1 rated the usability dimensions of relevance, efficiency, and attitude as equally important in both contexts. The dimensions of learnability and error management were rated as more important in the context of target designation. P2 rated the usability dimensions relevance and attitude as equally important in both contexts. The dimensions of efficiency and learnability were rated as more important in the context of civil navigation. Both subjects thus rated the dimension of error management as more important in the context of target designation. Overall, all subjects participating in the study individually rated the dimension of error management as more important in the context of target designation. The dimension of error management thus seems to be experienced as more important in high-risk scenarios such as the one in the target designation scenario.

Table 2. The mean value of usability dimensions rating depending of the contextual aspects of use of participant 1 (P1).

Usability dimension	P1 (Civil Navigation)	P1 (Target Designation)
Relevance	6	6
Efficiency	5.20	5.20
Learnability	4.5	5.17
Error Management	4.43	5
Attitude	5	5

Table 3. The mean value of usability dimensions rating depending of the contextual aspects of use of participant 2 (P2).

Usability dimension	P2 (Civil Navigation)	P2 (Target Designation)
Relevance	6	6
Efficiency	6	5.4
Learnability	5.67	5.33
Error Management	5.57	6
Attitude	6	6

5 Conclusions

All usability dimensions investigated in this study were rated as high in both the civil navigation scenario and the target designation scenario. All five usability dimensions were collectively rated as more important in the context of the target designation task as compared to the context of the civil navigation task. This implies that the context of use has an effect on importance ratings across all five usability dimensions. One explanation of the results could be that the context of target designation is experienced to be more crucial and associated with higher risks relative to the context of civil navigation and the usability dimensions are therefore rated as more important. The domain of high-risk and task-critical environments could explain the overall high importance rating of the usability dimensions. This implies that the methodological framework can be used to capture and discriminate fine grained differences in user experiences that can be crucial to systems development and evaluation in simulated scenario-based environments. This points at the importance of staying sensitive to design and use of scenarios and tasks when conducting usability evaluations in simulated environments.

6 Discussion

Overall, all usability dimensions were rated as important in both contexts investigated (civil navigation and target designation). This could be explained by the nature of the investigated domain where all usability dimensions should be of importance, no matter if a fighter pilot engages in target designation within visual range (WVR) combat or conducting civil (non-combat) navigation. However, there were some differences between the groups and the contexts investigated and all usability dimensions were rated as more important in the context of target designation. Especially the usability dimension of Error management was rated as more important in that context. This can be explained by the task in the context of target designation being more critical (limited time, stressful and hostile environment) and more risky, where minor mistakes can result in immediate and severe consequences, in other terms than in the civil navigation scenario.

The relatively high ratings of the usability criteria in the HMI survey imply that it is suitable to utilize usability measures during systems evaluation in the domain of fighter aircraft cockpit development.

The findings in this study are based on a small number of subjects. The population of experienced fighter pilots is limited and it is hard to access this group to participate in studies. This is a known challenge to system developers within this domain, which further stresses the importance, when having access to these users, to be able to get the most out of an evaluation session. It is simply not enough to ask participants if a button should be red or green. Previous studies describe that also different domains and user experience levels have an effect on the relative importance of usability dimensions (Frokjaer, Hertzum, & Hornbaek, 2000; Quesenbery, 2004)). This study was more focused on investigating the contextual aspects of use and showed that the contextual aspects of use had an effect also for this homogenous group of users within such a specific domain.

In HMI system evaluation it is important that the scenario used in evaluation is qualitatively tailored to distinguishing features of a certain context as well as specific features of the system functionality. This imposes strong demands on design and development of relevant scenarios where these aspects are considered and emphasized. The civil navigation scenario used for this study was by the subjects considered as very realistic. The scenario used for target designation was not experienced as equally realistic. However it is worth noticing that the high importance ratings in the context of target designation would perhaps have been even higher if the experience of realism of the scenario had been higher. One hypothesis is therefore that this could have led to an even higher difference in ratings of the usability dimensions in the two contextual conditions investigated.

The domain investigated in this study demonstrated that there were differences between the relative importance of the five usability dimensions due to contextual aspects of use. These differences are probably even larger between domains. The effect of contextual aspects on the different usability dimensions across domains, user experience levels, and tasks should be further investigated. In the future, this might lead to identification of weighting patterns reflecting importance ratings of the usability dimensions that may later be used for best practice within various domains.

Importance ratings of HMI criteria and usability dimensions could be used to capture contextual aspect of interaction during system development and evaluation. These can later be used for prioritizing the severity of revealed design issues in further iterations in the system development design process. The importance ratings should not alone serve as input to the design process. The ratings should be complemented with participant/user comments and justifications of ratings to lead to an even better understanding of the context (Strohmyer et al., 2010).

Promoting the use of importance ratings of usability criteria within system evaluation in combination with the use of representative and relevant tasks and users during simulated scenarios will leverage considerations of contextual aspects in evaluation. Thus, considering contextual aspects could serve as a success factor in system development and evaluation.

As emphasized within distributed and particularly situated perspectives on human cognition and acting in the world, the context in which the acting takes place is a key factor for understanding human cognition (Suchman, 1994). However, much of the HF literature adheres to a more rationalistic world-view that has come to criticism (Winograd & Flores, 1987) for prioritizing the individual and mental aspects of cognition (Ramberg & Karlgren, 1997).

In the study reported on in this paper, the relevance of usability aspects in two different scenarios representing two different contexts was measured. Results from the study show the complex relationship between the assessed relevance of usability measures and the two different scenarios. Thus, this study has with its experimental design and a homogeneous group of professionals shown that contextual aspects have settling importance when users are assessing the relevance of usability measures. Field studies are often proposed and even emphasized to be an integral part of determining a systems use qualities. Although we agree with this, it is in some cases, such as research within aviation, not possible to assess use qualities in the wild (Hutchins, 1995). Within aviation research, simulations therefore need to be conducted within controlled environments to test the usability of complex systems. In conducting these simulations and evaluations, one must stay sensitive to the design and use of scenarios and tasks.

7 Acknowledgements

This study was conducted as part of the Brain Budget project, sponsored by VINNOVA (Swedish Governmental Agency for Innovation Systems), within the National Aviation Engineering Program (NFFP). The project was a joint effort between Saab Aeronautics, Swedish Defence Research Agency (FOI), and Stockholm University.

The Brain Budget project focused on innovative and effective systems development for military aircraft in the area of Human Machine Interaction (HMI). The overall objective was to develop quantitative and qualitative HMI measures in order to assess the pilot's cockpit HMI to support the establishment of requirement analyses, specification, and closure.

References

Albers, M. & Mazur, B. (Eds.) (2003). Content and complexity: Information design in software development and documentation (p. 93). Mahwah, NJ: Lawrence Erlbaum.

Albers, M. J., & Still, B. (2011). Usability of complex information systems: Evaluation of user interaction. New York, NY: CRC Press, Taylor & Francis Group.

Artman, H., & Zäll, S. (2005). Finding a way to Usability: procurement of taxi dispatch system. Cognition, Technology and Work. Vol. 7(3), pp 141-155.

Benyon, D. (2010). Designing Interactive Systems. A comprehensive guide to HCI and interaction design. Essex, England: Addison Wesley.

Borgvall, J., Castor, M. & Bennett, Jr., W. (2009). Knowledge and skill-based evaluation of simulated and live training - From evaluation framework to field application. In proceedings of the International Symposium of Aviation Psychology 2009. Dayton, OH: Wright-State University Press.

Burke Johnson, R., & Onwuegbuzie, A. J., (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. Educational Researcher, vol. 33 (7), pp. 14-26. Sage Publications.

Carroll, J. (2001). Human-Computer Interaction in the New Millennium Addison-Wesley Publishing Co. New York, NY, USA.

Carroll, J. (2003). HCI Models, Theories, and Frameworks: Toward a Multidisciplinary Science. Morgan and Kauffman, NY.

Castor, M. (2009. The use of structural equation modeling to describe the effect of operator functional state on air-to-air engagement outcomes, Doctorial Thesis No. 1251, Linköping University, SE-581 83 Sweden.

Cresswell, J. W., & Clark, V. L. P., (2011). Designing and Conducting Mixed-Methods research. Sage Publications Inc.

Dumas, J. S., & Salzman, M. C. (2006). Usability assessment methods. Reviews of Human Factors and Ergonomics (pp. 109-140). Santa Monica, CA: Human Factors and Ergonomics Society.

Frokjaer, E., Hertzum, M., and Hornbaek, K. (2000). Measuring usability: Are effectiveness, efficiency, and satisfaction really correlated? Conference on Human Factors in Computing Systems (CHI-00) (N.Y., April 1-6 2000).

Harper R., Rodden, T, Rogers, Y. and Sellen, A (2008). Being Human: Human-Computer Interaction in the year 2020. Microsoft Research Ltd. Cambridge. http://research.microsoft.com/en-us/um/cambridge/projects/hci2020/download.html.

Hackos, J., & Redish, J. (1998). User and task analysis for interface design. New York: Wiley.

Hollnagel, E. & Woods, D. (2005). Joint Cognitive Systems: Foundations of Cognitive Systems Engineering. CRC Press, Taylor & Francis Group, FL.

Hutchins, E., (1995). How a Cockpit Remembers it´s Speed, Cognitive Science 19, pp. 265-288.

ISO 9241-210:2010. (2010). Ergonomics of human-system interaction, Part 210, Human-centered design for interactive systems. Geneva, Switzerland.

ISO 9241-11:1998. (1998). Ergonomic requirements for office work with visual display terminals (VDTs), Part 11, Guidance on usability. Geneva, Switzerland.

Jander, H., Borgvall, J., & Ramberg, R. (2012). Towards a Methodological Framework for HMI Readiness Evaluation. Proceedings of the Human Factors and Ergonomics Society Annual Meeting: Vol. 56. pp. 2349-2353.

Löwgren, J. (1993). Human-Computer Interaction. Studentlitteratur, Lund, Sweden

Markensten, E., & Artman, H. (2004). Procuring Usable Systems Using Unemployed Personas. Proceedings of NordiCHI'04, Tampere, Finland, October, pp. 13-23.

Mayberry, C. R., Jaszlics, S., Stottlemyer, G., & Fritz, G., (2012). Augmented Reality Training Application for C-130 Aircrew Training System. In proceedings of I/ITSEC, the Interservice/Industry Training, Simulation & Education Conference, NTSA.

Nielsen, J. (1993). Usability Engineering. Cambridge, MA: AP Professional.

Quesenbery, W. (2004). Balancing the 5Es: Usability. Cutter IT Journal 17(2), pp. 4-11.

Ramberg, R., & Karlgren, K., (1997). Fostering Superficial Learning. Journal of Computer Assisted Learning, 14(2).

Runeson, P., & Höst, M., (2008). Guidelines for conducting and reporting case study research in software engineering. Empirical Software Engineering, vol 14, pp. 131-164. Springerlink.com.

Shneiderman, B. (2009). Designing the User Interface: Strategies for Effective Human Computer Interaction. New York, NY: Addison & Wesley.

Strohmeier, D., Jumisko-Pykkö, S., & Kunze, K., (2010). Open Profiling of Quality: A Mixed Method Approach to Understanding Multimodal Quality Perception. In Journal of Advances in Multimedia, vol 2010. Hindawi Publishing Corporation.

Suchman, L., (1994). Plans and Situated Actions: The problem of human machine communication. Cambridge university press.

Suchman, L. (2007). Human-Machine Reconfigurations, Plans and Situated Actions. Cambridge University Press, NY.

Svensson, E., Angelborg-Thanderz, M., Borgvall, J., & Castor, M. (2013). Skill decay, reacquisition training, and transfer studies in the Swedish air force – a retrospective review. In W. Arthur, E. A. Day, W. Bennett, and A. Portrey (Eds.) Individual and team skill decay. New York, NY: Routhledge.

Tassakori, A., & Teddlie, C., (2003). Major Issues and Controversies in the Use of Mixed Methods in the Social and Behavioral Sciences. In: Tassakori & Teddlie (eds.), Handbook of Mixed Methods in Social & Behavioral Research, pp. 3-50, Sage Publications.

Usabilitynet. (2011). http://www.usabilitynet.org/tools/methods.html, Viewed 2011-04-21).

Vallstrand, J. (2009). Usability goals for administrative software. Master Thesis. Royal Institute of Technology, Stockholm, Sweden.

Winograd, T., & Flores, F., (1986). Understanding Computers and Cognition. Addison Wesley.

Woolrych, A., Cockton, G. (2001). Understanding Inspection Methods: Lessons from Assessment of Heuristic Evaluation. In: Blandford, A., Vanderdonckt, J., & Gray, P. (Ed). People and Computer XV. Springer-Verlag.

FOI, Swedish Defence Research Agency, is a mainly assignment-funded agency under the Ministry of Defence. The core activities are research, method and technology development, as well as studies conducted in the interests of Swedish defence and the safety and security of society. The organisation employs approximately 1000 personnel of whom about 800 are scientists. This makes FOI Sweden's largest research institute. FOI gives its customers access to leading-edge expertise in a large number of fields such as security policy studies, defence and security related analyses, the assessment of various types of threat, systems for control and management of crises, protection against and management of hazardous substances, IT security and the potential offered by new sensors.

FOI
Swedish Defence Research Agency
SE-164 90 Stockholm

Phone: +46 8 555 030 00
Fax: +46 8 555 031 00

www.foi.se