# Methodology Choices in Health Related ICT-Design

Marjo Rissanen

Aalto University School of Science and Technology, Finland

**Abstract.** ICT-supported health promotion has diverse development challenges. Methodological selections guide the design and development of solutions and artefacts and are critical in area where utility and cost-effectiveness are required of applications and systems. The article gives an example of an ICT-project at the occupational health which methodological choices and framing was considered from view of one popular guideline frame [11] in design science research in Information Systems. Good familiarity and understanding of the ideology of the frame are essential when trying to reach more sinew with aid of it.

**Keywords:** ICT-design, methodological framing, occupational health

## 1 Introduction

Health related ICT-design projects are typically pragmatic by nature and emphasize the usefulness of designed products. Also iterative product development is common in this field because long-lasting maturation phases are often the rule rather than the exception. Unfortunately even trial-and error searching would characterize development in health related ICT-design. Also balanced synergy between relevance and rigor and reliance on creativity are meaningful issues in this area. The ideas presented in these guidelines for design science research by Hevner et al [11] and their illuminating examples [10, 12, 13] emphasize aspects which are typical or desirable in health related ICT-design. Guidelines [11] are also actively discussed by other authors. Information systems (IS) design science research (ISDSR) has a common body of knowledge and a cumulative tradition [4]. There are also so called process models in the IS sector concentrating on the process chains of design [16] as well as models concentrating on paradigms, theories, taxonomies, or patterns in this area.

The goal of the integrated case study was to produce a supporting tool for occupational health promotion and training. The prototype was aimed at supporting blended health training programmes which combine classical class interventions and self-paced learning. The multidisciplinary production team consisted of domain experts from different fields. The author of this article worked in this project as the main designer and the project coordinator. This article describes how the given guidelines [11] refreshed with some newer specifications by Hevner [10], by Hevner and Chatterjee [13], and insights presented by other authors [e.g., 24] inspired by these guidelines fit the principles, ideas, and design practice undertaken in this project. In this



*In: H. Gilstad, L. Melby, M. G. Jaatun (eds.): Proceedings of the European Workshop on Practical Aspects of Health Informatics (PAHI 2013), Edinburgh, Scotland, UK, 11-MAR-2013, published at http://ceur-ws.org*

analysis formal reasoning and literature review were utilized with gathered experience.

## 2 Main ideas in guidelines

Design-science research provides contributions in the areas of design artifact, design construction knowledge, and design evaluation knowledge. The purpose is to create and evaluate purposeful IT artifacts which are intended to solve identified organizational problems or to address solved problems in more effective and efficient ways. [11] Design theories are an answer to developmental questions [12]. The model by Hevner et al [11] contains an information systems research framework and seven design guidelines. The presented guidelines assist researchers and designers to understand the principles and requirements for effective design-science research. The seven guidelines are following: design as an artefact, problem relevance, design evaluation, research contributions, research rigor, design as a search process, and communication of research. Hevner et al advice against mandatory use of the guidelines but remind that each guideline should be addressed in some manner in complete design-science research. [11] The goal of design science is utility and "*rigor must be assessed with respect to the applicability and generalizability of the artefact*" [12]. Design science in information systems research requires a wide range of scientific foundations and is derived from the effective use of knowledge base. In a rigorous design it is meaningful that "*design science research is grounded on existing ideas drawn from the domain knowledge base*" while inspiration for creative design can be drawn from multiple sources. The goal is also domain–independent understanding which means knowledge which can be applied to any research project. [12] Hevner [10] adds to this list so called "*additional sources of creative insights*" [2]. Wang and Wang [24] also emphasize the meaning of cross-disciplinary involvement and alignment in relevant design research. While rigor can be achieved "*by appropriately applying existing foundations and methodologies*" an overemphasis of rigor can even decrease relevance and artefact and focus environments themselves may defy excessive formalism [11]. Therefore, synergy between practice and theory is needed in good design science research [10].

In the presented model [11] it is emphasized that "*design as a search process*" requires experience, creativity, intuition, and problem solving capabilities with connected design iterations. The theory basis addresses both the process and the designed product. Problem solving represents a search process and a design artefact is complete when it satisfies settled requirements and constraints of the settled problem. In evaluation functionality, completeness, consistency, accuracy, performance, reliability, usability, and fit with the organization with relevant quality attributes are in focus. [11] Faludi [3] reminds that a problem is actually a relevant set of objectives: such a set is only seldomly possible to clarify at once and requires therefore iterative rounds of specifications. Finally design–science often simplifies a problem by decomposing it into simpler set of sub-problems [11]. Design research cycles are named as following: relevance cycle (requirements, field testing), design cycle (processes in design and evaluation), and rigor cycle (theory grounding, additional sources) [13]. To control

acceptance problems it is useful to understand the combination of technology-based, organization-based, and people-based artefacts [11].

Original guidelines inspired Wang and Wang [24] to present useful aspects in their contribution; design as a new layer "*can be useful not only for solving the existing problems in business but also for initiating new needs for business"*. They also remind that IT innovation can never be optimal; e.g., *"rigorous tests for an IT innovation design artifact might be difficult to define and might take longer time than the artefact's life cycle itself* ". They also point out that "*to reduce biases in research, it is necessary to conduct independent experimental tests that are outside of the design circle*". [24]

## 3 Methodological emphasizes in the project

### 3.1 Problem relevance and creativity in health related design

In the health sector the question is often stated as; how to create more beneficial, efficient, and user-centred services or applications? Problem relevance as a basis may empower the practical nature of the development process. However, this requires openness to identify and also realize so called "blind spots" in focus environment. Such a problem-driven approach is not too limited or stiff in its nature and it also makes genuine problem identification possible. It also means eagerness to find quite new paths, insights, and views in design process. Actually the question is about some kind of deep analysis of the focus environment. On the other hand this means true acceptance on the fact that the existing set of unsolved problems do not form the one and only source of inspiration [e.g., 24]. When searching research rigor in health care, so called additional sources of creative insights [2] should also have space. Besides making creative systems there is also a need to create adaptive systems for the sector. Gregor and Jones [8] highlight this issue with the term "*artefact mutability*" which means that artefacts are in an almost constant state of changes.

### 3.2 Methodological choices in the project vs. guideline framing

Insights presented in guidelines [11] can be identified in the methodological framing of this project. One aspect of the project was to develop an artefact which was aimed at support tutor-driven, blended programmes at occupational health. The main audience consists of employees of enterprises. The questioning focused on the following developmental challenges: how to generate a product which could support differently implemented learning phases (tutored and self-paced) and how could its evolution be guaranteed towards such adaptation which suits its focus environment but however could create more dynamics to its practices and thereby also manifest creativity aspects of design. The typical aspects of DSR were recognizable in this project: problem relevance, research rigor, design as a search process, design as an artefact, and plans for evaluation and communication. Research rigor in the project means specification and customization of a suitable theory framing. In this area the design activity typically requires multidisciplinary theory understanding to be useful in the situation.

The following Table 1 describes presented guidelines and connective design phases with their primary issues in this project.

**Table 1.** Design elements in the project based on guidelines by Hevner et al [11]

| Guideline | The main task & process |
|---|---|
| Problem relevance | Neck-shoulder disorders at work |
| Research rigor | Theoretical frames & specifications& creativity |
| Design as a search process | Design procedure & iterative development |
| Design as an artefact | Prototype & service product combination |
| Design evaluation | Evaluation during design, plans for follow-up |
| Research contributions | Significance & implementability evaluation |
| Communication of research | Interest groups & specifications |

## 4 Methodological choices and alignment with guidelines

### 4.1 Problem relevance

Health is one of the key components of workplace well-being [18]. In the occupational health sector there is a need for projects and tools which could motivate employees to take part in health promotion activities. Neck pain with its associated disorders is quite a common symptom, experienced in different situations and environments [9]. However, further research is needed to identify factors causing work related neck pain as well as to develop appropriate primary prevention strategies [e.g., 7]. The combination of high job strain and high perceived muscular tension is associated with a higher risk of neck pain than the combination of high physical exposure and high perceived muscular tension [22]. Only a minority of people with neck pain seek intensively health services [9]. Actually multiple visits and treatments may even worsen the situation [14]. Exercise training and mobilization are seen effective and beneficial examples for cure and prevention in non-traumatic neck pain [9]. Questioning focuses on the following aspects: how to create appropriate learning arrangements and how to optimize these with successful toolkit and method integration?

A clearly expressed mission is one element for well-focused artefacts and interventions. The purpose of the application is to offer more empowerment for health training and prevent neck and shoulder disorders and thereby enhance well-being at work. Flexibility in training was also targeted because too fixed models were not wanted. New kinds of health technologies are typically adopted by younger users with better health and less of those who would need those [25]. That means a continuous design challenge. However, it is important that health promotional activities are based on the voluntary interest of participants at least in the sense of what comes to provided training methods. Therefore, there is a need for differently organized training and options which take into account individual preferences (fully self-paced, blended, tutor-led).

### 4.2 Searching research rigor; theory frames and creative insights in design

When the complexity and multidimensionality in design task increases that often means a need for a more detailed theory inspection in spite of the possibility that the project could be occupied with experts for its every sub-field. In occupational health training the question is about learning and therefore connective theory basis forms one of the key frames. Health education combines many aspects from different disciplines. Medical knowledge, occupational medicine and health form the basis for instructional content design. Hence the quality and trustworthiness of offered information has a critical role. Theoretical understanding covers the overall attributes of information quality. Information quality contains aspects like relevance, accuracy, completeness, timeliness, and usability as well as users' ability to understand offered information [20]. Qualified information improves decision effectiveness whereas increasing information quantity impairs it [15]. Therefore, information filtering and compression in such a way which is not a threat to quality is of great importance.

E*ducational technology research* field, computer supported learning, and connected theory basis offer principles and models for best practices. *Socio-cultural approach of learning* focuses on questions of how individual and social learning would be integrated and emphasized in each situation. In the occupational field the training process may consist of different phases. Blended programmes utilize typically offline and online training phases. Blending ideology as such improves flexibility and helps to avoid excessive formalism when applying different learning approaches. The tutor can combine the models of *direct instruction and collaborative learning*. Direct instruction may be needed in informative intensive parts of training program and on the other hand, collaborative approach is useful when the purpose is to give much responsibility and space for learners' individual common contemplations and questions.

In this project *quality theoretical framing* underlines especially customer-, product-, process-, and ethical quality aspects. Customer quality means actualization of the principles of *user-centred design*. However, user-acceptance may actualize even with products with questionable value. Therefore product's real usefulness and its ethical acceptability are meaningful aspects. On the other hand, beneficial product without user acceptance is meaningless. In *software design quality* Budgen [1] highlights the aspects of reliability, efficiency, maintainability, and usability. Ease of use plays a critical role in system quality [17]. Actualization of these attributes needs to be considered along any project. *Design strategies* form the starting point for the overall design culture and is constructed around the principles of evidence-based-, user-centred-, and value-driven design emphasis. Finally, general *design theoretical approaches* customized for the health related ICT-sector offer guidelines for the toolkit design. Nowadays normal practices in occupational health give inspirations how to develop these protocols for a better fit which as such remains as a *creativity challenge*.

### 4.3 Design as a search process

Iterative development policy which gathers signals from different work environments and tries to maturate the product with the aid of these signals is well suited to this project. Hence, the development policy resembles ideas of software prototyping with

an aim to generate adaptive solutions. The training entity is a combination of a product, instructional methods, and focus environment. Therefore this integration design is an essential part of the project's implementation planning. Different work sectors have their own special needs and features and these emphases should be integrated into the design and implementation of the training entity. The purpose is that the application can be elaborated according to noted signals. However, the blending ideology itself gives flexibility and makes possible to integrate different techniques, methods, and emphases for each training intervention whenever sector specific wishes can be detected.

Hevner et al [11] refer to Gelernter [5] with the theme "*machine beauty"*; meaning "*the essence of style in IS design"* or combination "*between simplicity and power that drives innovations*". In the example project it was planned that the application can give sinew for classical classroom type learning interventions but also supports employees' self-learning periods. If applications which are targeted at self-management in health issues are too time-intensive in use this phenomenon may decrease the user's interest to adopt these for genuine utilization [6]. To find such a level which represents a reasonable simplicity but does not make a threat on quality issues means a dialogical search process. Compactness and straightforwardness are therefore some targets in design in this field and represent at least certain aspects of machine beauty.

### 4.4 Design as an artefact

"*DSR must produce a viable artefact in the form of a construct, a model, a method, or an instantiation*" [11] or it means improvements of existing IT artifacts or streamlining of solved problems [24, 11]. In this case the designed artefact forms one part of the training entity. The designed prototype consists of components like text, audio, illustrations, video clips (Fig.1), supporting tools for interactive sessions, and self-evaluative tests. The approach was planned to be holistic, and therefore aspects connected to neck related disorders and symptoms, like stress-related factors, issues connected to individual health management, and arrangements promoting well-being at work were included in the application. These theme areas form an entity in which each theme has its specific task and role.

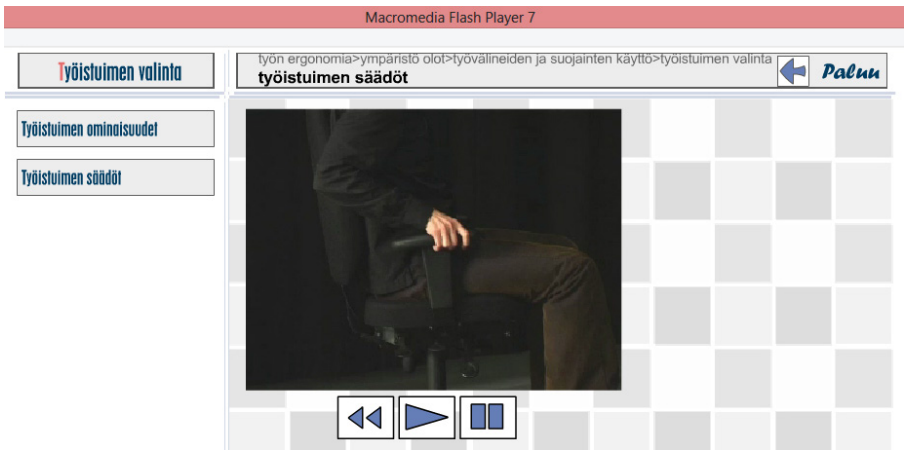


**Fig. 1.** Working environment; adjusting the seat

### 4.5 Design evaluation

The mission of the project and product combination is to deliver more well-being for employees (the primary outcome level, mission level). The sub-mission level means the planned service concept. This means evaluation of the application and its ability to support tutored and self-paced learning as well as evaluation of the connected instructional processes (the service level; *design cycle*). In artefact evaluation it is meaningful to test whether the artefact and its embedded functional principles form an answer to the presented meta-requirements [23]. When the product is an essential part in framing the training entity, each training experience gives insights; how to develop the prototype towards better adaptation. This practice represents the iterative cycles of design. Another aim in this project was to create better adaptation and "*to pay attention to toolkit's internal operations and interactions with its environment*" [e.g., 19]. Planned desire was that the feedback gathered in training situations could give data for product maturation. The evaluation during design with the prototype consisted of test situations with individual users. These test results led to design iterations and also represented formative evaluation during the project. Evaluation during design covered one training situation for a group of employees in the early design phase.

The evaluation of the framing theory basis in the project means evaluation of the instructional and pedagogical approaches, quality aspects, and design principles (the framing level; *rigor cycle*). This customization work represents area of "*research contributions*" concerning area of theoretical foundations. Environmental frames, organizational requirements; different work places may have their own specific needs. These represent organization-based structures and systems which should be taken into account in the area of technology acceptance [11]. Hence, success of this integration design forms one evaluation point (contextualization level; *relevance cycle*) (Table 2).

**Table 2.** Model for the evaluation in the case

| Categories | Level type | Subject | Focus in evaluation |
|---|---|---|---|
| Mission level | Outcome | Work well-being | Long-lasting effects |
| Sub-area: *Design cycle* | Service | Service concept | Usability of artefact & service concept |
| Sub-area: *Rigor cycle* | Design frames | Methods, theories / creativity | Theory fit, integration & customization |
| Sub-area: *Relevance cycle* | Context | Organizational requirements | Service-environment integration |

The product or service is the combination of an application (*technology-based artefact*) and a training programme (*people-based artefact*) and hence this entity should form a satisfying experience for the participants. However, satisfaction of participants does not tell much about the actual, wanted outcome (better ability to cope with neck pain resulting in enhanced well-being at work). Helpful IS design means consideration of the long-term challenges [24]. The perceived usefulness and satisfaction of participants can be evaluated after each training entity. On the other hand the targeting of the primary mission and the longitudinal effects can be tested only with time. Tutors' observations during training interventions and its analysis are naturally important evaluation sources. Evaluative focuses and the iterative design cycle must in this case also cover the entire service entity (pedagogical approaches, lecturing content, supporting application, contextualization component). The evaluative focus should cover several aspects of quality; customer-, process- and product quality categories are naturally in primary focus, but attributes of efficiency and ethics are equally important areas of assessment.

### 4.6 Research contributions and communications

Hevner et al [11] emphasize the novelty, generality, and significance of the designed product when most often all attention is on the appearance of the artefact itself. In this case the application and planned training process together form the service product. At the moment the presented artefact offers an option for training challenges at the occupational health. Training sessions with action research arrangements are one flexible way to communicate the ideas and also to learn new aspects to be considered. In best case the purpose of DSR is also to offer extensions or enhance the level of theoretical foundations and methodological frames. In this case it offers one example of the connected frame combination which comes into question with needed customization and specifications without further extensions or development of theory framing. However, in this field most of the projects need innovative insights as a part of grounding frames and in this way may also offer catalytic validity value.

## 5 Conclusions

This study deals with methodology aspects grounded with a case study around a health promotion project. Methodological framing and process chain in the project are

studied according to the principles presented in guidelines [11] for design science in information systems research. The ideology embedded in these guidelines with their connected specifications was recognizable in this project.

In generally the methodology frame by Hevner et al [11] can support IT-projects by systematizing their design protocols. However, it is important that this framing and its features are known and understood clearly enough. Hevner et al [10, 11] refer to other authors and remind that beside the theoretical frames, creativity is an important inspirational source and too much rigor emphasis may even disturb relevance. Profound understanding in applying can give sinew but also needed balance and reduces this way gap between theory and practice in health related IT-projects. In their discussion Wang and Wang [24] offer useful insights which are relevant in health sector. In this sector all problems are not visible and therefore existing identified problems or already, at a certain degree solved problems can not be the only inspirational source for design. IT innovations are needed in enhancement of current structures and systems as well as in creating quite new artefacts for the area. In this area relevance in design of IT innovations means always a versatile understanding of those quality aspects which are needed in evaluation throughout the design and development. In the whole health sector effective information delivery forms a complex area with its growing needs. The problems to be handled are not self-explanatory and therefore besides multidisciplinary expertise there is also a need for concentration on design challenges and issues from the view of methodological choices. In ISDSR body of knowledge also contains various useful emphases and models with their specifications for design philosophy. Finally, as Venable [21] states further work in this research area is welcome.

## References


1. Budgen, D.: Software Design (2nd ed.). Pearson Addison-Wesley (2003)
2. Csikszentmihalyi, M.: Creativity: Flow and Psychology of Discovery and Invention. Harper Collins, New York (1996)
3. Faludi, A. Planning Theory. Pergamon Press (1973)
4. Fischer, C.: The Information Systems Design Science Research Body of Knowledge – A Citation Analysis in Recent Top-Journal Publications. PACIS 2011 Conference Proceedings (2011)
5. Gelernter, D.: Machine Beauty: Elegance and the Heart of Technology. Basic Books, New York (1998)
6. van Gemert-Pijnen, J., Nijland, N., van Limburg, M., et al.: A Holistic Framework to Improve the Uptake of eHealth Technologies. Journal of Medical Internet Research 13(4), e111 (2011)
7. Green, B.: A Literature Review of Neck Pain Associated with Computer Use: Public Health Implications. JCCA. 52(3), 161-168 (2008)
8. Gregor, S., Jones, D.: The Anatomy of a Design Theory. Journal of the Association for Information Systems 8(5), 312-335 (2007)
9. Guzman, J., Haldeman, S., Carroll, L., et al.: Clinical Practice Implications of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine 33(4), S199-S213 (2008)

10. Hevner, A.: A Three Cycle View of Design Science Research. Scandinavian Journal of Information Systems 19(2), 87-92 (2007)
11. Hevner, A., March, S., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly, 28(1), 75-105 (2004)
12. Hevner, A., Winter, R.: Interview with Alan R. Hevner on ”Design Science”. Business & Information Systems Engineering 1(1), 126-129 (2009)
13. Hevner, A., Chatterjee, S.: Design Research in Information Systems. Theory and Practice. Integrated Series in Information Systems 22, 33-42 (2010)
14. Hurwitz, E., Carragee, E., van der Velde, G., Carroll, L., et al.: Treatment of Neck Pain: Noninvasive Interventions. Results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Eur. Spine J. 17(1), 123-152 (2008)
15. Keller K.L., Staelin R.: Effects of Quality and Quantity of Information on Decision Effectiveness. J Consumer Research 14(2), 200-213 (1987)
16. Peffers, K., Tuunanen, T., Gengler, C., Rossi, M., Hui, W., Virtanen, V., Bragge, J.: The Design Science Research Process: A Model for Producing and Presenting Information Systems Research. In: Proceedings of DESRIST 2006. pp. 83-106. (2006)
17. Rai, A., Lang, S.S., Welker, R.B.: Assessing the Validity of IS Success Models: An Empirical Test and Theoretical Analysis. Information Systems Research 13(1), 50-69 (2002)
18. Schulte P., Vainio, H.: Well-being at Work-overview and Perspective. Scand J Work Environ Health. 36(5), 422-429 (2010)
19. Simon, H.: The Sciences of the Artificial, MIT Press, Cambridge (1996)
20. Stacey, P., DeLone, W., McLean, E.: Measuring Information Systems Success: Models, Dimensions, Measures, and Interrelationships. European Journal of Information Systems 17, 236-263 (2008)
21. Venable, J.: Design Science Research Post Hevner et al.: Criteria, Standards, Guidelines, and Expectations. In R. Winter, J. Zhao, and S. Aier (Eds.): DESRIST 2010, LNCS 6105, 109-123 (2010)
22. Wahlström, J., Hagberg, M., Toomingas, A., Tornqvist, EW: Perceived Muscular Tension Job Strain, Physical Exposure, and Associations with Neck Pain among VDU Users; a Prospective Cohort Study. Occup Environ Med. 61, 523-528 (2004)
23. Walls, J.G., Widemeyer, G.R., El Sawy, O.A.: Building an Information System Design Theory for Vigilant EIS. Information Systems Research 3(1), 36-59 (1992)
24. Wang, S., Wang, H.: Towards innovative Design Research In Information Systems. Journal of Computer Information Systems 51(1), 11-18 (2010)
25. Weingart, S., Rind, D., Tofias, Z., Sands, D.: Who Uses the Patient Internet Portal? The Patient Site Experience. J Am Med Inform Assoc. 13(1), 91-95 (2006)