Collaborative Process Modelling and Evaluation in E-health

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Abstract

There is a gap in Design Research literature regarding context and methodologies for Evaluation. The Evaluation stage is the bridge between Design (or procurement), and Benefit management. Taking a constructive approach to the many challenges this poses, we propose a framework for e-health design research evaluation. We perform a systematic literature review for the use of process modelling notation in e-health. This is a prerequisite for process and service co-creation and evaluation. We further assess these, as they are applied in the literature, for cognitive efficiency in communication between receiver and sender.

Keywords:

Design Research, Process Modelling Notation, Business - IT alignment, E-health, Evaluation.

Introduction

In many highly industrialized countries, the increase in elderly citizens in need of care is growing. We see rising quality expectations for the provided care with the increase in the level of welfare. Service innovation and process improvement is needed to close the gap between the workforce that will be needed with today's processes, and the available future workforce. Unfortunately, e-health innovation is still especially challenging (1, 2).

The public, or semi-public context, of e-health in Norway, means that there are several stakeholder categories to consider. System development is potentially costly, and the innovation risk is high. Ex-ante evaluation of problem statements and design objectives of an emergent solution can help mitigate this risk.

Stakeholder expectations in e-health

The public context of the e-health domain in many countries often leads to different stakeholders in the role as users and buyers of services. In general, new e-health artefacts (e.g. Methods, Processes, Performance indicators, Information systems, Organization models, and Business models) risk failing to meet their objectives because they fail to meet all the stakeholders' expectations and requirements. A possible taxonomy of stakeholders in e-health could be based on four groups (fig. 1):

- E-health acceptors (e.g. patients, patients next-of-kind, patient-groups, and -unions)
- E-health providers (e.g. primary care, hospitals, and medication-suppliers),
- E-health supporters (e.g. IT vendors and universities),
- E-health controllers (e.g. government, legislators, financiers, and insurance companies) (3).

An example of failing to meet all stakeholders' expectations and requirements is Google Health (4). Among the reasons for its failure is that they largely ignored the requirements and expectations from both doctors and insurance companies.

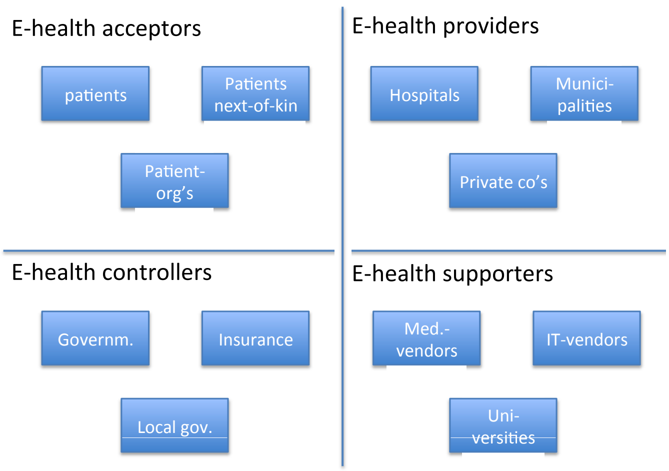

Fig. 1 The Multi-actors of e-health. After (3).

A possible taxonomy for the main elements of value propositions for new processes and services can be found in design literature (5-7):

- Feasibility - Can it be done?
- Viability - Does it make sense, economically or does it provide enough benefits vs. its cost. Other factors might be price, tax, insurance etc.
- Desirability - Do the intended users want this?

As healthcare is both a public and private/individual domain, the latter could be subdivided into a public subdomain e.g. survival rates, increased average living years, and a private subdomain, e.g. Quality of Life (Q.o.L.) and Quality of WorkLife (Q.o.W.L.). These domains combined with the mapping of main stakeholder groups provide an Evaluation scoreboard that can serve as a framework for evaluation of new e-health process improvement initiatives, see fig. 2.

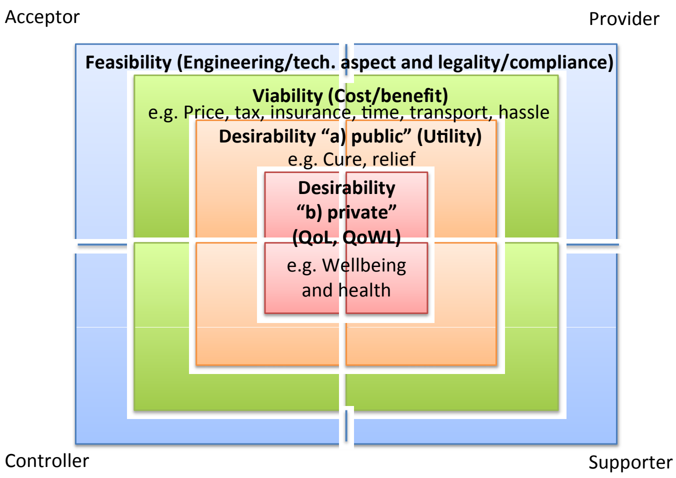

Fig. 2. Framework for e-health process evaluation. After (3, 5-7).

Methodologies for Design Research

Design research is a growing area of interest. There is a call for Information systems (IS) research to return to exploring the underlying IT (Information Technology) engineering and its domain-knowledge premises in IS (8). The epistemology and ontology of design research has been debated (9, 10). An emergent consensus in the debate seems to be that although design research can reflect any epistemological stance, it embodies a pragmatic nature. Design research can revolve around human artefacts that can't be "true" in the positivistic ontological sense of the word, but rather more or less useful (11). There also seems to be a consensus that regardless of stance, research needs to be done in both a relevant and rigorous manner (12).

To help us perform design research, in a both relevant and rigorous manner, different frameworks methodologies have been devised such as Design Science Research (13) and Action Design Research (ADR), see fig. 3 (14, 15).

The different design research methodologies share many of the same main activities, but emphasize different activities. ADR (15) main characteristic is the Action-role of the researcher. Through intervention the researcher works in a team with practitioners and users.Here special attention given

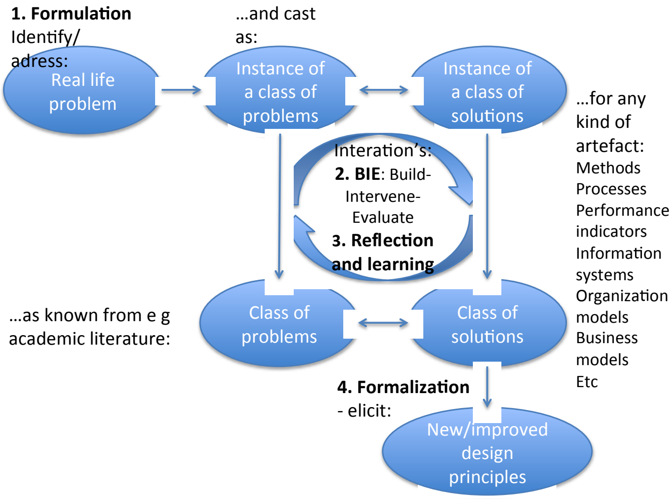

Fig. 3. Action design research activities. After (15).

to the classification of problems and solutions with regards to the research state-of-art. Peffers and colleagues emphasize the "Build" or design phase. We can illustrate this focus with the corresponding design research opportunities in parentis in the following process (16):

1. Identify a problem [or purpose] and motivate a new solution (Problem centred initiation)
2. Define the objectives of the solution (Objectives centred initiation)
3. Design and development of the artefact (Design and development centred initiation)
4. Demonstration (Client/context centred initiation)
5. Evaluation
6. Communication

The process should be iterated if necessary. See the illustration below (Fig. 4). We see that Evaluation is not assigned any research opportunity in this model.

Evaluation criteria and methods are left to choice as to how the testing and Evaluation of new solutions should be performed (13, 16).

This paper proposes a framework for evaluation in the e-health context. This paper also provides an overview over some commonly used process modelling notations and techniques in e-health. These models and notations are then evaluated for suitability in collaborative process co-creation based on a framework for assessing cognitive efficiency in communication between sender and receiver (18, 19), see table 1.

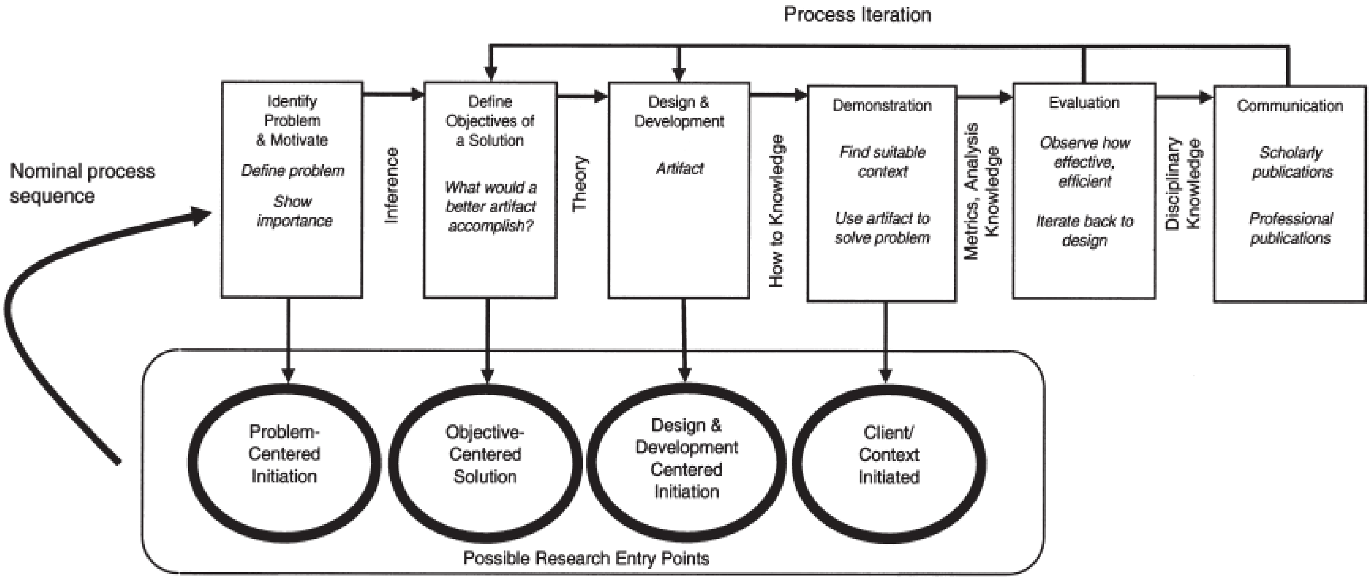

Fig. 4. Design Research Model. After (16)

Table 1. A framework for cognitive efficiency. After (18, 19).

Concept	Explanation
Semiotic Clarity	A 1:1 correspondence between semantic constructs and graphical symbols
Perceptual Discriminability	Different symbols should be clearly distinguishable from each other
Semantic Transparency	Use visual representations whose appearance suggests their meaning e g "Rich pictures"
Complexity Management	Include explicit mechanisms for dealing with complexity: Avoid overloading the human mind, e g Hierarchical organization: Abstraction-summarization vs Decomposition-refinement
Cognitive Integration	Include explicit mechanisms to support integration of information from different diagrams e g Contextualization: each diagram should include its surrounding context to show how it fits into the system as a whole
Visual Expressiveness	Use the full range and capacities of visual variables (Visual freedom)
Dual Coding	Use text to complement coding
Graphic Economy	The number of different graphical symbols should be cognitively manageable
Cognitive Fit	Use different visual dialects for different tasks and audiences e g novice perception problems

This framework aims to achieve cognitive efficiency in communication between sender and receiver. Cognitive fit is especially important in e-health, as co-creation involving patient groups require that a joint perception is possible. The principles may enhance or weaken one another, e.g. Visual Expressiveness may be in conflict with Graphic Economy, so different solutions represent a trade-off.

E-health innovation often entails inter-organizational process collaboration. Garmann-Johnsen and Eikebrokk (2) performed a literature review showing current knowledge according to literature on the antecedents of success in such collaborations. 11 of the 50 revised papers entailed cases of relevance to e-health.

We re-analysed this in depth to look for patterns for success in e-health innovation. We found very few clear examples of success stories, but the ones we found can in general be summarized as describing stories about successful alliance forming and management. When re-examining the data we also saw that success was recorded as seen from a particular perspective. Successful alliance management and beneficial (Action) Design Research thus dictate that all relevant groups are represented and become “co-creators” of new services (20).

A prerequisite for this collaboration is the ability to share a joint representation of such an intangible artefact as a process- or service-improvement. Modelling notation can serve as a boundary object, “physical objects such as design drawings, maps, contracts, learning materials, etc. that are used to facilitate cooperation while allowing diversity in interpretation” (21, p. 3). Several methods for modelling have been applied in e-health such as Business Process Modelling Notation (BPM-N) and a variety of Unified Markup Language (UML) diagram types. These are often used in combination. The next section provides a summary of a systematic literature review, mapping the use of modelling methods. We also provide an evaluation based on the cognitive efficiency of the examples of use given in the reviewed papers. This evaluation of use of methods is based on the compliance with the principles listed in table 1.

Literature review

We performed a systematic literature search to establish state-of-art for process modeling and notation in the healthcare contexts that are of relevance to IS-research. The literature search covered the academic databases that we deemed as likely to cover the most relevant subjects (cf. Table 2). EBSCOhost was used to search several databases for interdisciplinary journal articles.

In addition, a more refined search in ProQuest was conducted in order to search for possible secondary papers not found in the first search. We refined the second search based on experiences from the first. In total we found 435 articles, reduced for duplicate findings. We used truncations like '*process*', '*modelling*', '*notation*' and '*health* (OR) hospital*' in the two searches, to cover the area of 'service robotics' in clinical support systems and the Boolean operator 'OR' giving 'e-health', 'healthcare' and 'hospital'/'hospitals'.

Screening the search results

As our search was concerned with services and work processes we excluded articles dealing with Biology, Biochemistry, Biotechnology, Medical trials, Ecology, BioInformatics, Statistics, Medical ontologies, Demography, Research methods and other non-related themes.

The screening done by one of the authors was pair-reviewed and revised by the other. Thus we elicited 38 articles containing relevant knowledge.

Table 2. Literature review search strategy

Date	Database	Search string	F1	F2	F3
28/04/14	EBSCOhost all databases	(*process* OR *modelling *) AND *notation* AND *health*	101	81	22
29/04/14	ABI/Inform (ProQuest), all databases	*process* AND *modelling * AND *notation* AND *health* NOT …	358	354	16
SUM				**435**	**38**

Note: F1 = Total number of articles, F2 = Articles reduced for duplicates, F3 = Articles containing relevant knowledge for this study.

The 38 articles found and deemed relevant for our area of interest was:

EBSCOhost; (22), (23), (24), (25), (26), (27), (28), (29), (30), (31), (32), (33), (34), (35), (36), (37), (38), (39), (40), (41), (42) and (43)

ProQuest; (44), (45), (46), (47), (48), (49), (50), (51), (52), (20), (53), (54), (55), (56), (57) and (58) (contact first author for detailed table overview).

Findings

Our analysis of these relevant articles found 45 different concepts of modelling. 36 of these could be described as graphical notation systems, where some articles applied a combination of two or more notational systems. While finding many different notational systems there were still 9 out of the 38 articles with no reference to any graphical notation system. 13 articles contained notational systems only found in a single instance.

The most often used graphic notational systems were (see fig. 5). :

1. Diagrams associated with Unified Markup Language (UML); Use case diagrams, sequence diagrams and flowchart or activity diagrams.
2. Business Process Modelling Notation (BPM-N).
3. User Requirement Notation (URN). This system consists of two complementary sub-languages called Goaloriented Requirement Language for goal modelling, and Use Case Maps for scenario modelling(36).

We also rated the articles using graphic notation systems in process modelling, for Overall Cognitive Efficiency Rate, giving 1 point for every criterion in Moody and colleagues' framework being met (see table 1). We found that the most used notation systems usually met many of the listed criteria. The highest score was given to articles using the URN notation system. The notation systems used in single articles meet few of these criteria. Some candidate design principles for use of graphic notational systems in process modelling could be elicited from this rating:

1. Articles that used more than one type of notational system in combination achieved a higher Cognitive Efficiency Rate, especially the Complexity Management criteria and Cognitive fit.
2. To supplement the more formal diagrams with more informal "Rich pictures" provide better Cognitive fit and Semantic transparency.
3. UML flowcharts or activity programs could improve their Cognitive Efficiency Rate by adopting the "swimlanes" symbol from BPM-N thus clarifying responsibilities for different stages in a process.

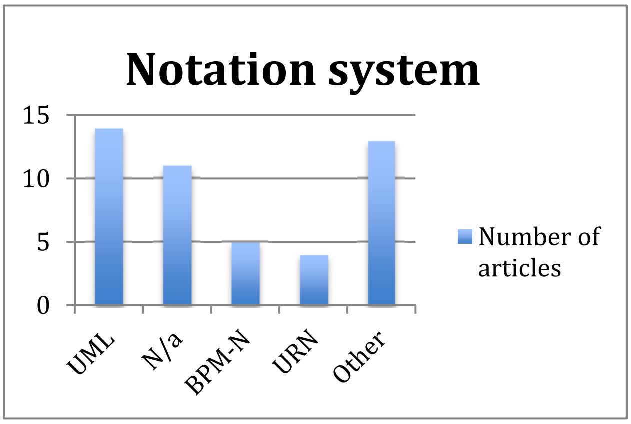

Fig. 5. Notation system per articles

Some articles (23, 25, 31, 32, 35, and 37) where no formal graphic notational system was reported used did contain what could be described as meta-models. These articles used alternative models to provide a background or a richer understanding of the problem in question. This could be theoretical lenses, political programs or other paradigm that describes the antecedents of problem solving and provides methods for understanding problems. One example could be the social model of disability that is recognized by disabled people and groups as an alternative to traditional models. This new model provides an alternative understanding expanding on individualized disability to also include social, political and cultural factors (46). Seeing disability as a broader "social, political and cultural" challenge will make action design researchers and practitioners look for other types of solutions than when seeing it as primarily an individual challenge.

Discussion

There is a research gap in design research literature regarding the Evaluation phase. This is a challenge that needs to be addressed. A multiple stakeholder perspective should be taken into consideration when designing or implementing a new e-health process change. High assumption innovations are associated with high risk for failure. Asking a representative selection of stakeholders based on what problem needs addressing can mitigate this risk.

As we have shown, graphic notation systems used in a combination that meets the requirements for cognitive effectiveness in communication (18, 19), can enable the discourse between stakeholder groups when evaluating proposed new process or service. Agreeing on a joint holistic understanding of the problem area of concern in each respective context will ease the discourse between stakeholders, as shown earlier in the Social vs. the Individual Model of Disability (46). Decisions often need to be a pragmatic compromise, as society's collective economy puts restraints on what levels of utility and quality is achievable (viable).

Enabling co-creation

This is an area of growing concern. The interest in especially eliciting the users and the general public's requirements for service innovation in public sector and e-health is growing. Research has provided honed methods for collection of data. Surveys and quantitative analysis, qualitative analysis using coding and aggregation of statements into concepts, and Q-sorting (59, 60) can be used to form inter-subjective user requirements for new more efficient healthcare processes and services.

Graphic notational systems as enablers of the co-creative design process are still developing. In addition to the applied notation systems our review has shown, new systems are emerging. One example is the User Experience Modeling notation where the patients take active part in the modeling process (61).

A coherent framework for e-health process modelling and evaluation

We see a need to involve stakeholders when evaluating e-health initiatives and a need for cognitive efficiency when involving stakeholder groups. Based on these findings we have defined six propositions that constitute a framework for evaluating new e-health processes:

1. Identify stakeholders and pick or recruit representative informants
2. Clarify the problem-perception between all stakeholder groups
3. Formulate problem and viable classes of solutions
4. Invite competing alternatives for (instances of) solutions
5. Evaluate and prioritize, using the E-health Process Evaluation Board (fig. 2.)
6. Elicit design principles for classes of solutions

1. Identify stakeholders and pick or recruit representative informants

Figures 1 and 2 contain four main- stakeholder categories (acceptor, controllers, providers, and supporters) and a few examples of subcategories. Relevant stakeholders in each applied case, depends on the specific context. Often a new process has an impact beyond first users, so all individuals or groups that are influenced directly or indirectly should be considered stakeholders. The sample size of a representative group of stakeholders depends on the method used for data collection (i.e. large scale experiments with control-groups (13), surveys, Delphi-methods, interviews, focus-groups, Q-sorting (59))

2. Clarify the problem-perception between all stakeholder groups

How problems are classified, or what theoretical lenses are used for problem elicitation, influence which solutions are sought (46). Discussing and clarifying problem perceptions and theoretical lenses for a discourse with stakeholder representatives will help focus the hunt for the best solutions, as seen from a multi-stakeholder perspective. E-health researchers can facilitate such discourses for the general public by representing relevant models and scenarios using

"Rich picture" notation (18). Allowing for ambiguity of perspectives in this stage can be beneficial, as the different categories of stakeholders or even subcategories should be allowed to hold subjective opinions.

3. Formulate problem and viable classes of solutions

Defining which class of solutions each specific solution belongs to will facilitate a better evaluation of competing solutions. Each class of solutions must address the defined problem or problem area (class of problems). Again one should allow for a certain ambiguity as to problem definitions and appropriate avenues for solution. The solutions should be presented for the stakeholder-representative group using the same graphic notation system and diagrams, making a comparison by the stakeholder representatives possible. At least one of the diagram types used should be suited for discourse with the general public, providing a "Cognitive fit" (18).

4. Invite competing alternatives for (instances of) solutions

A human artifact, such as an e-health method or process, will not be "true" in a natural science sense (10). It can only be found better or worse than some chosen alternative according to some chosen criteria. Such criteria might be within the aspects of feasibility, viability and desirability (public and private). Choosing a good solution, necessitates a completion with amongst more than one viable solution.

5. Evaluate and prioritize, using the E-health Process Evaluation Board (fig. 2.)

Formulate questions for the test and rating of feasibility, viability and desirability (public and private), for each stakeholder-category (acceptors, providers, supporters and controllers). The test can be adapted to each stakeholder-category, but should be controllable in the sense that it's the same for each solution alternative. The scale used should be the same for all stakeholder categories and solution alternatives, giving the possibility to facilitate decision-making by having comparable scores (indicators).

6. Elicit design principles for classes of solutions

In a range of competing solutions, it would be possible to identify and elicit which factors differentiate the best-ranked solutions from the worst. . These factors can again be cast as design principles reflecting existing or new theory. These design principles can be tested for any other instance of the defined class of problems.

Contribution/implication for Research/Practice

Our paper contributes to the literature on design research by detailing a practical way of eliciting new design principles through stakeholder evaluation. We also contribute a practical methodology and rationale for the use of comparable process modeling notation, to facilitate co-creation. This facilitates collaborative iterations in Building, Intervening and Evaluating solutions (15).

Our propositions for an evaluation framework can produce a baseline for indicators that can be utilized in process management and benefit management in public sector. This framework might also facilitate public-private collaboration where the choice of the better solution is based on a holistic view of the alternatives and not solely on price-competition between standardized and un-innovative solutions.

Further research

Further research for this proposed framework for evaluation of e-health processes would entail applying it in different case studies covering different classes of problems. The applicability of the framework in other fields of research in the public sector might also be explored.

Limitations

Our proposal does not cover all aspects of evaluation in design research. Nor does it concern other related aspects as system development, business models, or project management.

The literature review on process modelling and notation in e-health cannot give an exhaustive picture of the state of art here, as our search strategy or screening may have its limitations.

Conclusion

We have provided a proposal for a framework for evaluation of new e-health process and services that supplement existing literature on design research and e-health research.

We have shown that our propositions may have an impact for both research and practise. Further research will be to apply this framework to case studies in the e-health context or other related public sector contexts.

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