11-28-2018

Principles for unbounded secondary design

Magnus Rotvit Perlt Hansen
Roskilde University, magnuha@ruc.dk

Jan Pries-Heje
Roskilde University, janph@ruc.dk

PRINCIPLES FOR UNBOUNDED SECONDARY DESIGN

Research paper

Hansen, Magnus Rotvit Perlt, Department of People and Technology, Informatics, Roskilde University, Denmark, magnuha@ruc.dk

Pries-Heje, Jan, Department of People and Technology, Informatics, Roskilde University, Denmark, janph@ruc.dk

Abstract

End-user redesign has been coined as a phenomenon that may happen within IT platforms such as Facebook or Wikipedia. However, redesign or secondary design outside the boundaries of a platform is under-researched. Existing prescriptive knowledge is limited to designing functionality of an artefact with specific boundaries where redesign can take place, not on why and how to enable novel unbounded redesign outside the original scope that can benefit decision making and organisation. Hence, we need design theories that can help primary designers create artefacts that allow unbounded secondary (re-)design. We propose design principles for this unbounded secondary design. The principles are derived from a group decision support tool case that was presented, redesigned and infused into two different organisational domains. Thus, the contribution of the paper is a design theory in the form of two times three design principles aimed at supporting the secondary design process and the form and function of the secondary design.

Keywords: Secondary Design, Infusion, Diffusion, Design Principles, Implementation, Form and Function.

1 Introduction

The advent of IT-based social media has started a new age of how to design large platforms that support creation, sharing and consumption of user-based content. Open platforms such as Facebook, LinkedIn or Wikipedia are all designed with the intent of being altered by the users after the initial implementation and while the platforms are being used. Functionality such as enabling the possibility of third-party development of games, quizzes etc., or the ability for users to create groups themselves are all examples of users redesigning their personal space to fit their needs. This phenomenon of redesign after implementation has been studied in many contexts and used with many different names, such as appropriation of technology (Davern and Wilkin, 2008), malleable design (Gill et al., 2013), and secondary design (Germonprez et al., 2011). The latter concept of secondary design is especially interesting because it proposes design principles for how to design for open platforms as content-frameworks that are user-provided, user-diffused and user-consumed (Germonprez et al., 2011). From a secondary design point of view, a primary design of a platform is designed with the intent of being altered, yet still very strictly bound to whatever the platform allows. Typically, social media platforms allow changes in content, structuring of content and changes of the intended functionality- but not a completely new form or function because the primary designers are still surveying the use, tailoring the platform according to how it changes, and most importantly they are still the content owners. This is for example the case for platforms such as Facebook, LinkedIn and Snapchat. For consumer-oriented platforms, this can certainly be a good thing. For organizations that desire bespoke IT that are developed in-house, adapted and used rapidly, and provide freedom for employees to tailor tools to their own needs, the original boundaries of the primary design can be a hindrance for adoption, especially for groupware technologies (Jonathan Grudin, 1994). Put shortly, IT platforms have the disadvantage of being "gatekept" by primary designers well within the implementation and operations phase, and this may in turn provide hindrances for tailoring functionality of tools in an ever-adapting market. Designing for more unbounded possibilities of redesign may be a viable strategy for quick adaptation. We see a lack of principles for understanding how to design for unbounded redesign or secondary design. In the following study, we focus on the unbounded redesign of group decision support tools that can be used to evaluate and improve work practice, and address the research question of: *"What are the design principles for unbounded secondary design?"*

We identify the unbounded secondary design process as a process of *reinvention* (Rogers, 2003) within the diffusion of innovations (DOI) paradigm. In DOI, the users' needs and desires for an innovation can be influenced by five central attributes of the design: relative advantage, compatibility (of values and prior processes) complexity, trialability and observability (of usefulness or beauty) (Rogers, 2003). We argue that a primary designer can change these attributes through design principles of both form and function, and thus influence the adoption rate through principles of how to support the secondary design process. We coin the term *unbounded secondary design* because the process of redesign is intentional, yet the remaining result is to a large degree (though still within the primary design structure) up to the users themselves. This way, the secondary design unfolds based on the process and actions taken by the primary designers in the initial introduction and is then borne by the structure and design possibilities of the primary design. While it might not be truly unbound, the foundation for creating additional artefacts are as *unbound as they can get*. The focus of unbounded secondary design distinguishes itself from earlier secondary design studies where the original intent of technology from the primary designers remains somewhat intact. We contribute to Design Science Research (DSR) by showing the importance of having both principles of form and function and process-based design principles alongside each other, and we further contribute to the secondary design concept by providing new principles for how to design for a specific class of secondary design technology not hitherto identified.

The remainder of the paper is structured as follows. First, we present previous research on the phenomenon of redesign by end-users with a specific focus on the design principles and the types of technologies involved, specifically focusing on the relation to decision support systems (DSS). Second, we present our method as a qualitative multiple case study of how two end-user redesign processes unfolded from the same primary design of a decision support tool. Third, we go through the distinctive episodes of the cases and how they related to design principles of both implementation (what was done by primary designers to enable the secondary design) and form and function (what functionality that supported the secondary design artefacts). Finally, we discuss our findings and conclude the paper.

2 Previous Research

Here we present previous research on the phenomenon of end-user redesign and on design principles and design theories within design science research for decision support systems.

2.1 End-user redesign

The general phenomenon of end-user redesign has been known by many names. Within diffusion of innovations theory Rogers (2003) coined the term "reinvention" as the phenomenon of users using technological innovations in ways not intended by the designers in the first place (Rogers, 2003). Innovations are often more prone to adoption when their attributes show a relative advantage, compatible with previous values and practices, their complexity match the problem they solve, are observed to work as well as testable first. Reinvention is specifically prone to occur when innovations are complex, open-ended and designed to solve more than a single problem. Reinvention has been defined as "the degree to which an innovation is changed by the adopter in the process of adoption and implementation after its original development." (Rice and Rogers, 1980, pp. 500–501). The reinvention concept has been applied to ERP systems (Boudreau and Robey, 2005) and surveillance systems (Fedorowicz and Gogan, 2010). In the organisational context, "appropriation" has been used as a similar term for users' circumventions or workarounds to fit technology into the current prevalent work practices (Davern and Wilkin, 2008). This specific phenomenon has been proposed to hold a strong learning value for developers and designers as well as organisational benefits for top management since a redesign following the practical workarounds of the technology can yield strong productivity benefits (Tyre and Orlikowski, 1994) and even opportunities for complete organisational change (Orlikowski and Hofman, 1997).

However, when we know that end-user redesign will occur at some point after the technology has been implemented, why not attempt to support this through specific functionality? The term 'malleability' has been proposed to solve this intentionally by making designers aware that configurability can be built into the artefacts and thus pre-emptively solve many of the issues that users can create by 'hacking' the artefacts (Gill et al., 2013). For example, with the concept of malleability, Gill and Hevner (2013) define customisation as the ability for users to change certain preferences of the technology; integration as combining technologies; while extension is defined as having the possibility of adding new capabilities to the designed artefact. The idea that users themselves can be offered functions supporting configurability of the artefacts has further been researched within the confines of minor technologies and applications with cooperation and collaboration capabilities (Richter and Riemer, 2013).

The concept of end-user development takes this one step further (Fischer et al., 2004). End-user development is an attempt to propose an overall design process called *meta-design* where a design is *seeded* by designers into the organisation, then users are taught to learn how to change the design through easier-to-learn coding languages throughout an *evolving* phase where changes to the design are unfinished and tested out (by users), and then finally the design is *reseeded* by the designers in the final stage. This model was coined the "SER" model and proposed as a result of realising that many requirements of functionality are discovered at run-time (Fischer et al., 2004). End-user development has primarily been researched using controlled tests by letting users solve problems using spreadsheet technologies that were later adapted into minor applications (McGill, 2004), thus advocating the idea that users can design and develop tools from scratch when and if they need to. The area of end-user development still seems confined to users who have the competence to work technically and with solutions from scratch.

Finally, the one research stream that seems to embrace both intentionality of end-user redesign through functions and content manipulation is that of "secondary design" through tailorability (Germonprez et al., 2011). Secondary design is a type of design where the whole purpose of the design is that it will be changed by the users. In secondary design, two cycles of design exist: the primary design inscribed and constructed with the intentions of one or more primary designers, and then following a secondary design cycle where the end-users are meant to design the primary design further to either better fit with the context or develop it for new contexts. The design principles for tailorable secondary design include that designers should provide ways for flexibility without locking the users into specific tasks and common, standardised practices, best done through recognisable and modifiable components that can easily be re-arranged by the users (Germonprez et al., 2007). The technologies that have been researched with secondary design has been those of platforms within the consumer domain such as Wikipedia and Facebook, where the underlying logic of the technology remains untouched while the content and functions can be manipulated freely by users. Text, presentation and general semantic content are defined as the "content" layer, while links, navigation and integration, even the "softer" rules of how the community of users should best engage with the content, are called the "function" layer. Furthermore, two central dualities have been identified in tailorable secondary design that explains the relationship between technology and people: planned and emergent, denoting the intentions of the designer and the design-in-use, and participation and reification, denoting how users participate and create meaning by making the structures of a system or social relation *seem* real and physical (Germonprez et al., 2011). The secondary design concept has been used to research principles on evolutionary business IS where user-driven ad-hoc changes, content and instance development, control flow adaptation as well as creating feedback channels by letting users control and change an e-learning IS themselves have been proposed as important findings (Neumann et al., 2014).

2.2 Design principles for group decision support systems

Decision Support Systems (DSS) are systems that support decision making. Group decision support systems (GDSS) are systems that supports a group of users in making decisions. Facilitating a decision process for a group can be both complex and difficult (Aiken et al., 1991). On one hand, the group-oriented design demands strong designer competences, while on the other hand, the actual content of what needs to be facilitated to assist a group in making decisions rely heavily on the decision context and knowledge (of which the user group involved are experts). This has brought with it many proposals of design principles for form and function of DSS and GDSS to help designers.

Originating from organisational decision-making processes, the overall structure of a DSS has been defined into the phases of 'Intelligence' (assessing the situation), 'Design' (proposing contextual solutions) and 'Choice' (letting stakeholders make decisions) (Simon, 1977). In newer literature, this structure has been refined into more specific areas, though with an intact general workflow structure of how to assists users making decisions through problem recognition, definition, generating and analysing alternatives, and making and implementing the choice (Shim et al., 2002). The pioneering principles included a focus on the confidence of users' decision making through *user calibration* of the aspects of expressiveness, visibility and inquirability of symbols and representations (Kasper, 1996). Kuechler and Vaishnavi (2012) also proposed guidelines for how to design the specific interfaces and representation of information to optimise decision making (Kuechler and Vaishnavi, 2012).

As the field of Design Science Research has matured, more emphasis has been given on how to provide design theories for classes of problems and technologies. The purpose of DSR is to look into how to solve specific problems through designing solutions and prescribing theories for how to solve abstract problems related to these classes (Gregor, 2006; Gregor and Hevner, 2013; Hevner et al., 2004). As such, theories in progress, or so-called nascent design theories, must include principles that designers can follow in order to solve new problems within the same class (Heinrich and Schwabe, 2014; Walls et al., 1992). A central distinction of principles is that principles can be focused on either "form and function" that explain the physical attributes and constructs of the artefact, or "principles of implementation" that explain how to go about implementing the artefact as a process, or even using it (Gregor and Jones, 2007). Principles of implementation are exemplified by the definition of *causa efficiens* by Aristotle as the mediator and creator of the artefact, e.g. a carpenter whose processes of designing and constructing a table need to be explicitly known. A similar distinction can be found in software engineering, where one can distinguish between what makes good software as a product and what makes good software as a practice. Baskerville et al. (2003) note that the process-oriented principles are even more important than the product in itself.

Principle of DSS from Markus et al. (2002)	Type of principle	Inferred designer action
#1: Design for Customer Engagement by Seeking Out Naïve Users	Form and function	*Do something with the users to put into the design*
#2: Design for Knowledge Translation Through Radical Iteration with Functional Prototypes	Implementation	*Do something with the users to put into the design*
#3: Design for Offline Action	Form and function	*Do something to the design*
#4: Integrate Expert Knowledge with Local Knowledge Sharing	Form and function	*Do something to the design*
#5: Design for Implicit Guidance Through a Dialectical Development Process	Implementation	*Do something with the users to put into the design*
#6: Componentise everything	Form and function	*Do something to the design*

Table 1. Characterising principles for DSS by Markus et al. (2002)*, with our comment on the principles in terms of what the principles lead designers to do.*

Very few nascent design theories are explicit in their delineation of principles of form and function and on implementation, though. For example, many prescriptive design principles have proposed that designers need to *do something* with either the design or with the users of the design in order to achieve functionality of the design artefact that corresponds to the requirements of use of an input into the system (Aiken et al., 1991). One of the first explicitly pioneered *design theories* proposed that DSS to support emergent knowledge should follow six principles, reproduced in Table 1.

The principles for DSS by Markus et al. (2002) primarily revolve around *doing something to the design* or *doing something with users to put into the design* and not on what primary designers should do to make the design work on implementation. We acknowledge the importance of functionality of the artefact but we also want to emphasise that secondary design is contingent on the experiences with the design as well as on the designers and their actions. We argue that for secondary design processes to flourish, the principles of implementation of the primary design in GDSS settings are under-researched and need to be related to the principles of form and function.

3 Research Method

Two longitudinal case studies were performed of how a primary design evolved into secondary design over time. The purpose was to establish a "replication logic" by contrasting results (Yin, 2009). The two cases differed in their organisational domain, one being a hospital in Northern Denmark, henceforth denoted *NOH,* and the other being a high school in Roskilde, Denmark, henceforth denoted *RHS*. Common for the cases was that the secondary designers both had taken the same executive master education in project management where the primary design was presented as part of the curriculum. We studied both cases through observations, interviews and artefact analyses throughout the secondary design process. In NOH, the study took nearly a year and for RHS about 5 months. In total six interviews and observations of use were held with the secondary designers from case NOH, while 2 formal interviews and 3 unstructured, informal meetings as well as a full-day observation of use were held with case RHS. Interviews were recorded, summarised, analysed and coded 24 hours after each interview was held. Both cases provided access to their final secondary design. We distinguish between the artefact focus context (the context that the artefact revolves around solving a problem for) and the implementation domain (the overall organisation of the artefact). Case NOH designed one instance that was configured to their context of project management and domain of healthcare, while case RHS designed four instances with different contexts relating to the high school domain. This ensured that the secondary design artefact instances could be analysed broadly (two different domains) and deeply (various different contexts within the same domain).

The empirical material was analysed as a process model (Van de Ven, 2007) where different episodes with different outcomes were categorised as leading up to the existing outcome event (in this case, the final secondary designs). Within IS, process models have been especially successful in explaining phenomena that occur over time such as developer/user relationships (Newman and Robey, 1992) or relation between software development and organisational change (Bygstad and Nielsen, 2012). In our case, we analysed the overall process of the redesign in terms of how the secondary designers provided value into respectively what the primary designers did during the process, and how the initial structure of the primary design helped them change the design over time. Episodes were chronologically ordered with the primary and secondary actions described during the episodes. Each episode was labelled with a principle either relating to the actions of the primary designers, or a principle of form and function of the artefact that enabled the secondary designers to progress in the process of redesign.

4 Two case stories of emerging principles

As noted prior, we decided to undertake two longitudinal case studies presented in this section. Both cases shared the same primary design. We analyse and elicit principles of implementation and principles of design of form and function as the case stories progress.

4.1 The primary design

The two cases shared the same primary design. The primary design was called "the project radar" and was initially used by project managers from a banking organisation as a tool to identify problematic issues of an existing project in an organisation through assessing, overviewing, reflecting and making decisions for projects based on an agreed-upon baseline. The artefact supported emergent knowledge processes (EKP) (Markus et al., 2002) and could be categorised as a decision support system (DSS) (Shim et al., 2002).

The primary design was derived from an action research undertaking in a major bank (Avison and Pries-Heje, 2008) and the design was as such completely unrelated domain-wise to the secondary design cases. The meta-requirements included that project management, as a discipline, overall is a very tool-heavy discipline. This makes it difficult for a project manager, green or experienced, to navigate and use the right tool for the right problem in a project, as projects differ by variables in variance of size, aim, and number of stakeholders (to name but a few).

Meta-requirements is a way to generalize a specific set of requirements from a case (Walls et al., 1992) into more general settings and thus decouple the relevance and solve problems of a class of related areas. Meta-requirements for the project radar were divided into technology (a need for user input to visualize values of overall parameters), domain (organisational process) and context (individual practices through actions and facilitation). The meta-requirements were instantiated into an artefact using an interactive (Excel-based) spreadsheet with data visualisation of a radar tool. Based on a literature review, a number of dimensions were identified to make up the "intelligence" part (searching for problems) of the tool. Thus, to use the tool a project manager would answer questions related to 8 dimensions including "project task", "knowledge about project", "individuals and background", "environment for project", "project team", "calendar time", "stakeholders", and "quality/criticality". After answering a survey that put data into a benchmarking algorithm for these dimensions, the tool generated a visualisation of the current status of the project (the "design" part of the decision support process). The overall output of the artefact was a visualisation in the shape of a radar chart where the project manager could see which areas could be problematic and based on these, a number of recommendations for each question and dimension and for the project as a whole was provided (the "choice" part of the decision support process). An example was the dimension of "individual and background" where a potential issue could be that project participants experienced that too little time or resources were allocated to the project. The tool was meant for creating learning through reflection providing the project manager with possible suggestions, methods, techniques and approaches to solve potential problems.

The content layer of the primary design consisted of three primary components: A) Questions based on 8 parameters on a 5-point likert scale; B) A visualisation that created an overview of all parameters on a single page using a radar chart; and C) Proposals of improvements by taking specific actions based on the values of the questions and parameters and on a visual metaphor based on project archetypes.

The functional aspects of the primary design of the three primary components consisted of: A) How to input the answers to the questions, manually or using a dropdown menu; B) An automated benchmarking algorithm to aggregate the values of the questions based on the number of questions within each parameter, as well as the scale preferences of the radar; and C) A dedicated connection between answers to dimensions and the project management tools and aspects to be presented.

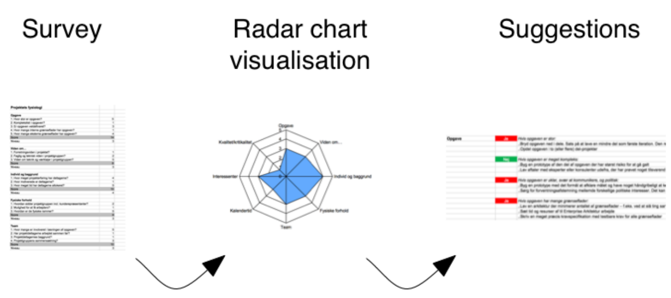

Figure 1. Showing the three components and the sequence of the primary design of the decision support artefact (letters are unreadable on purpose)

Thus, the components consisted of a flow of a structure (Figure 1) that was simple and could be re-arranged to a certain degree, though the largest changes possible were presentation, calculations, and how and who to use the tool within a practical context and domain.

4.2 Presenting the advantages of the primary design

The primary design was presented as a tool that could make it easier for project managers to select relevant project management tools for a specific project. The artefact focus context was thus project management, common for the users' background as they were learning about project management. To learn how to use the primary design, the users would try out the primary design on their own projects in their own organisation. As a result, the users could observe the potential and advantages themselves.

In the NOH case, there were two project managers with more than 20 years of working experience. They were inspired by the primary design and felt that the context of project management could be applied to the project managers and participants in their own organisation: a hospital.

"My great 'heureka' moment was after using [the tool] […] and we were visually able to see where our challenges were and confirm our suspicions we had when we were part of the project." – Secondary designer B, case NOH

In the RHS case, a project coordinator saw a strong potential to apply the tool at a local high school in four separate student contexts, thus redesigning the primary design four times! The first secondary design was implemented in the "Study Direction Project" (SDP); a major project that the students have to undertake in their 3rd year of high school where they are meant to focus and problematize a specific topic that shapes the direction of their studies, supervised by a teacher. The following three secondary designs revolved around teaching students how to be better at writing English essays, preparing them for their social studies exams, and teaching students how to navigate socially and technically using social media, the internet and general information technology. The advantages that the project coordinator saw here included that a redesigned tool could help the students understand their own potential and help the supervising teachers engage in better dialogue with their students based on a common visual representation.

"It was really good teaching where I felt I could see the applicability. The teacher [the primary designer] spent a lot of effort showing what needs the project radar can fulfil, how it was developed. And I realised that ok, it really is similar to a high school setting." – Secondary designer K, case RHS

This made it clear that despite commonalities the primary design could not stand on its own. The presentation, documentation and use of the tool were not enough to invoke the secondary design process. Rather, engaging with the potential secondary designers and showing and explaining the advantages of the tool in a dialogical process assisted them in seeing the primary potentials. From the reactions to the presentation of the primary design tool, we elicit the first principle of implementation (DPI1): **Principle of presenting diffusion attributes.** Ideal unbounded secondary design support should clearly be supported by communicating and showing the concrete instances of the innovation attributes of relative advantage, compatibility, complexity, observability and trialability.

4.3 The contingency of adapting design to context and domain

Motivation was key, yet work had to be done to refit the primary design. The presentation of the reason behind the primary design in terms of specific attributes along with the initial use of the primary design artefact (the spreadsheet tool) motivated the secondary designers to realise how it would fit their own domain and relevant contexts. Explaining the process of the primary design and its initial meta-requirements made the secondary designers realise some of the potential benefits. The primary design context in the NOH case was kept within project management with only a few changes to some of the attributes and questions. This came from a need to move the otherwise generic project management practice into the specific practice of healthcare, where certain attributes would not fit with the usual practice. One of the designers noted that:

"It could be really interesting if we had the possibility to change some of those questions, or parameters on the level of tailoring it for us, because we do not have projects with 300-400 employees, we have a completely different context." – Secondary designer B, case NOH

In the RHS case, the context was only partially project management-oriented in the sense that student projects to a large degree are individually performed. Instead, the context was changed to fit with the specific details of the individual growth and development of students that was primarily focused on individual learning, performance and growth:

"Some of the areas were completely obvious parallels that could simply be transferred. Some of the parameters in the project radar that you need to fulfil in a project, you need those in a high school project as well." – Secondary designer K, case RHS

This made it clear that primary designers need to engage in activities that support de- and reconstructing the context, domain and the technology. From the inception of the secondary design process, we elicit the second principle of design implementation (DPI2): **The principle of instantiating meta-requirements into the domain, context and technology.** Ideal unbounded secondary design should support showing the interdependency of how the solution previously has been fit contextually, and technologically in a specific domain as well as the process from general meta-requirements to specific instance.

4.4 Exhibiting new and relevant possibilities

One central aspect of motivating the secondary designers to see potential was in the form of having the primary design constructed as two different instantiations: 1) a paper-based version; and 2) an interactive IT-based spreadsheet. This made it possible for the secondary designers to choose which degree of automation and manual work would fit best, both in regards to their own technical competence but also according to the recipient. The secondary designers of the NOH case, for example, were convinced that they would never be able to persuade their users to input values into a spreadsheet. Instead, they opted for a much simpler implementation:

"So we created a form, just like the tabloid quizzes, where I filled it out while talking about [the project radar] during the interviews." – Secondary designer A, case NOH

Case RHS took another approach. The users here were students and teachers who were all quite comfortable with using technology. As a result, the spreadsheet was immediately adapted and upgraded. No more than a couple of months later, a javascript-based website was hosted that let students log in and do their own input into the system for further assessment by their supervisors at a later time.

"The spreadsheet was a brilliant tool for me because it was really "hands on", […] otherwise I am not sure I would have ever tried changing [the design]. – Secondary designer K, case RHS

The multiple versions of the primary design made it clearer to the secondary designers how they could have changed and adapted the tool for the different contexts and domains. Based on the various technological levels of adoption and redesign by the secondary designers, we elicit the first principle of design of form and function for secondary design (DFF1): **The principle of constructing versions with varying degrees of automation.** Ideal unbounded secondary design should include multiple versions of the design on different levels of technology, e.g. from paper-based functioning artefacts to web-based functioning artefacts etc.

4.5 Making content and functionality transparent

Following the previous principle, having multiple versions of the primary design further supported rich information and multiple knowledge sharing mediums for how to do benchmarking for the questions and parameters, as well as for tailoring the value thresholds for proposals of related actions. This meant that the basic structure of the design made it easy for the secondary designers to follow the flow of use of the tool and manipulate it accordingly. In the case of NOH, the performance of the process of filling out the radar with the users was central and thus the two designers needed to be able to coordinate filling out values while interviewing and reviewing the preliminary results.

”We determined to use both a paper-based version and an electronic form, […] because we needed something quick and usable within 60-120 minutes, […] and it worked well” – Secondary designer A, case NOH

In case RHS, the secondary designer was convinced that the transparency helped him in manipulating the values and actually test it multiple times prior to implementation:

”[I would be] reviewing the parameters and check if I agreed in the formatting, and I had to adjust some of them, [...] if you score x and y, certain recommendations would occur, and I needed to pilfer in each area to see how [the project radar] reacted. And it required a crazy number of tests, retests and crash tests.” – Secondary designer K, case RHS

The essential white boxing of the technology made it much easier for the secondary designers to see which parts of the technology needed to change and also gradually adapt the tools to their own contexts and domain. From the reactions to the ease of changing the tool, we elicit the second principle of design of form and function for secondary design (DFF2): **The principle of transparency of technology**. Ideal unbounded secondary design should be constructed so the secondary designers are able to look ‘under the hood’ of all the underlying design, such as algorithms, functions, and data representation and calculation. This makes it possible for enabling both change of content as well as the configuration of the fundamental functionality of the design.

4.6 Allowing designers to learn through use

As already noted with principle DFF1 of construction of multiple versions, the design comfort and experience of secondary designers can vary greatly. An important activity that the primary designers performed was to let the secondary designers be comfortable in how to use the primary design through multiple, minor steps. In the teaching scenario, this included creating an environment where the primary design could be used *ex ante* prior to being used in a real setting. Evaluating the solution was not only important for learning about the design but also for learning *how to redesign*.

Case NOH chose to learn which parts of the requirements were important to change by testing out the primary design first, thus gaining knowledge of how the design should be used in the domain and how to change the context to a better fit. This was also the process whereby they learned which degree of automation was necessary (as stated earlier).

”But if we are going to test it out for real and redesign it, adapt it to our world, we need to do [prototyping]. We cannot just change it. Now we have knowledge and experience which make it possible for us to start somewhere, and much more qualified.” – Secondary designer B, case NOH

Case RHS also used prototyping as an evaluation method, though in a different way. Since the primary design domain and context had to change drastically, the secondary designer had to do expert interviews with the two types of intended end-users before testing out the tool in a real context.

”I started out by playing with these parameters and asking which ones are useful at face value, which ones make sense in the high school area and which ones do I need to reformulate. Then I started with the parameters and asked the students: “The scope of the task, what do you think about that?” And

they would say "the number of pages to write". I then used that input and started to ask the questions for the parameters and ask the students what they would understand by those questions" – Secondary designer K, case RHS

As a result, the actions of letting the secondary designers initially try and use the primary design for facilitation within the original context of project management further motivated the secondary designers to learn from the tool and to determine its usefulness. It was essentially the beginning of the initial learning process between designers, technology and end-users. From the process of evaluating the designs to learn how and what to design, we elicit the third principle for secondary design implementation (DPI3): **The principle of supporting experiential learning through prototyping**. Ideal unbounded secondary design should support the possibility of trying out the design to enable learning of the design and with the design. As the potential secondary designers can be on various comfort and design experience levels regarding technology awareness, domain and context knowledge, performing prototyping design sessions will greatly raise awareness and the competences of how to redesign the primary design.

4.7 A structure of building blocks

In both cases the secondary design came about as a result of an iterative process of designing and evaluating. The formative evaluations led to improvements in the design which in turn led to new learning points from formative evaluations and so forth.

In the NOH case the dimensions "individual and background", and "environment" were replaced with "implementation" and "communication" and new questions were phrased for these dimensions.

"We need to be able to find a score and recommend x and y, because that is what helped us; how did it look in practice?" – Secondary designer A, case NOH

Rather than getting results immediately, the secondary designers of NOH also supplemented the product with a manually written report for the specific projects with proposals for how to solve the existing problems that they identified.

"That is was did it for me; receiving something visual, a picture at the end. And that could be communicated to others rather than simply use numbers; the picture could be used to talk through and about" – Secondary designer B, case NOH

In the RHS case, the application domain changed to a student environment and the secondary design changed all 8 dimensions, e.g. to "subject and scope", "time", "digital skills", "technical knowledge", "resources", "technical communication", "information search", and "supervision" with completely new questions created to fit with the dimensions required of the Student Direction Project. Furthermore, the implementation guidelines were changed so that a student would use the artefact prior to the first meeting with his/her supervisor and then together with the supervisor select actions and techniques that could help improve their competences.

It was especially important to deselect certain aspects of the tool to fit with the didactic situation, which in this case was an individual dialogue between supervisor and student:

"Right now [the radar] is meant as an individual student tool to support independence and working with their own projects. But if you had a didactic situation with one teacher and 20 students, it might have made sense to include a typology with metaphors for a "varnishing day" [...] where they could talk about what to do if your radar looked like a mosquito pattern."- Secondary designer K, case RHS

The structure of building blocks further aided the secondary designers in changing various parts and sequences of the tool based on their evaluation activities. From the balance between following the flow and configuring the components, we elicit the third principle of design of form and function for secondary design (DFF3): **The principle of configuration-based component flow.** Ideal unbounded secondary design should be structured with loosely coupled components complemented with a clear rationale of their overall structure.

4.8 A design theory as two times three principles

Based on the two cases of secondary design we have now elicited three principles for design of form and function and three principles for design process implementation, inter-weaved and related them in a specific process sequence. The sequence of these principles constitutes a process design theory for group decision support systems that support work practice learning and reflection called “unbounded secondary design” (Figure 2). We propose that these principles and their sequence can be used by primary designers that aim at allowing and encouraging secondary design.

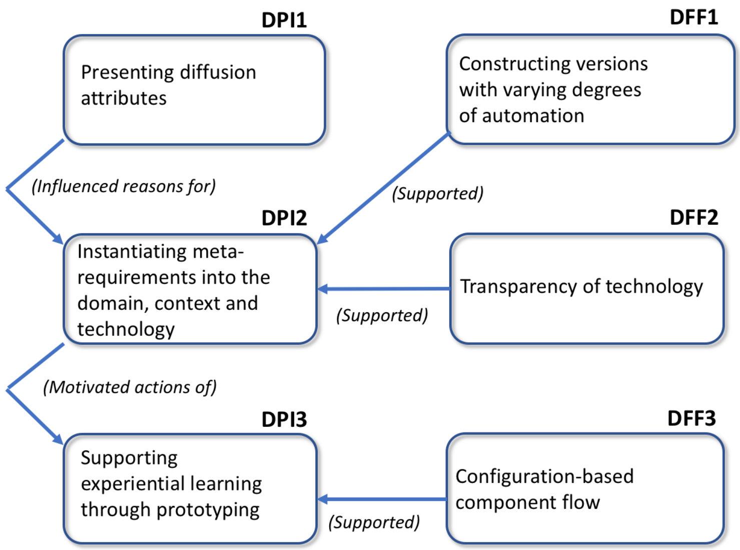

Figure 2. Showing the sequence of principles of design process implementation (DPI) and design of form and function (DFF) in a process model sequence.

5 Discussion

We contribute with a set of principles that can be followed by primary designers when their aim is to create a primary design that can be also be used for unbounded secondary design. This can be especially valuable for organisations where the competence of the employees is held in high esteem from management and where there is room for users to create tools themselves that later can be assessed, revised and bolstered into more platform-oriented tools. The principles derived were based on five instances; one instance of secondary design from the healthcare domain (the NOH case) as well as four instances of secondary design from the education domain (the RHS case). The secondary design was *unbounded* in the sense that the primary design was not designed with functionality that supported the secondary design in itself (as opposed to platforms where users are encouraged to manipulate content and functionality). Rather, we show how the functionality of primary design and the actions taken by the primary designers enabled users to become unbounded secondary designers by exporting the primary design into new contexts and domains. We further contribute by showing how principles of form and function can work in tandem with design principles of implementation. While certain principles are not new seen from a design point of view, we argue that the application of principles in the secondary design research area, along with relating principles of form and function with principles of implementation, is. For example, design principle DFF3: “Configuration-based component flow” has been proposed in primary design settings prior, e.g. to increase reuse for primary designers and closely related to software engineering principles (Baskerville et al., 2003; Bourque et al., 2002), or the notion of componentisation of DSS (Markus et al., 2002) and also as an important ability for secondary design (Germonprez et al., 2007). However, in our case, we showed why the componentisation was important and how this would fit into the process of the secondary designers: they needed these components in order to prototype and learn more about how to change the primary design artefact.

The principle of transparency of technology (DFF2 in Table 2) is related to the principle by Gill and Hevner (2013) of Open Design. The difference here is of epistemological nature. We argue that transparency and openness cannot come alone from thorough documentation, as this would assume that potential secondary designers already have a thorough technological competence. Transparency is not only about openness, it is also about the ease of helping secondary designers with 'opening the hood' of the artefact, hence aiming at the level of technological competence for the potential secondary designers. When a primary designer then combines the principle of transparency (FF2) with the principle of multiple versions (FF1), it makes it easier to look under the hood, as several versions exist with the same core content and functionality. It can also be argued that looking under the hood is dangerous in the long run, especially if the secondary design artefacts need to the properly diffused into the organisation. We acknowledge this and call for more research on the matter of how these types of unbounded secondary design artefacts fare in organisations in the long run.

With the introduction of design implementation principles, we further find a new use of Rogers' diffusion properties in DPI1, the principle of presenting diffusion attributes. Rogers (2003) found that innovations diffuse better in social systems due to perceptions of a relative advantage, low complexity, compatibility with values and habits, easy trialability, and high visibility of advantages. For unbounded secondary design, we argue that these characteristics as attributes of the design further need to be followed up by the primary designers to better increase adoption and adaptation, not unlike the proposal of the meta-design in end-user development (Fischer et al., 2004). Our case differed in the sense that users with very little technical competence and knowledge were still able to perform secondary design purely based on their motivation and view of relevance to their own domain.

Our second principle DPI2 of instantiating meta-requirements into domain, context and technology can be compared to the original formulation of meta-requirements by Walls et al. (1992). The original formulation, however, was never meant as an inherent ability of the artefact itself but rather as the process of how to design the artefact. Within secondary design, we see our contribution of this principle as a further addition to the primary design that these meta-requirements should also be communicated visibly to enable the unbounded secondary design process.

Similarly, the use of prototyping according to DPI3 has been acknowledged time and time again as being good design practice. Nevertheless, we found that the experiential learning aspect for secondary designers was an essential aspect for transferring ownership of the primary design to the secondary designers, and thus a necessary enabler. For example, the second case RHS very determinedly used prototyping not only as a way to evaluate the existing design but also to create and diffuse multiple secondary designs into the organisation.

While we acknowledge that each principle in isolation may not reveal much new insight for the average designer or practitioner, the dyadic nature and order of the principles that we presented do indeed represent new theory for the secondary design literature. For example, configurability, malleability and customizability are all a central part of the principles DFF1 and DFF3, though they will most likely not in themselves support an unbounded secondary design. Similarly, it has already been shown that configurability of components for DSS that draw on emergent knowledge processes is a central and well-known design principle (Markus et al., 2002). We do not argue against this, though we do acknowledge that our model of design principles depicts an order wherein actions taken by primary designers supported reconfiguration of the DSS where the inherent artefact functionality in itself would not have been enough.

Implications for practice include that with a more structured understanding of both types of principles, primary designers can take advantage of creating primary designs that are reinvented on individual, group and organisational level and create robust "bottom up" changes in the organisation. One can also argue that the unbounded secondary design artefact can be seen as a feedback loop for primary designers to consider the next version of the artefact. While it might not be attainable to have a fully unbounded design, seeing as a primary design will always to some extent be steered by its original intent, we argue that for certain settings it can be desirable to design for. However, our results are not without limitations and considerations, and unbounded secondary design is most certainly not desirable for all organizations. For production-oriented organizations that are structured with a tight amount of control, standardization, and governance, unbounded secondary may not be desirable. As a result, we call for more research on design theories where both types of principles are investigated and used practically. Further research should focus on different types of artefacts in different contexts and different domains, as well as focus on the model of the principles and whether certain principles have more merit than others.

6 Conclusion

We have now proposed a design theory for group decision support systems where there is a strong need for bottom-up diffusion among end-users. We have presented two times three principles constituting a design theory for "unbounded secondary design" for a group decision support system tool, a process design theory prescribing principles for actions taken by primary designers and a sequence of when principles of form and function and principles of implementation of the primary design enable secondary design to be redesigned bottom-up in an organisation.

We contribute to theory on design science research by showing that under certain design scenarios, a stronger distinction between principles of form and function, and principles of implementation is important, and also needed. We add to the body of knowledge of design theory for decision support systems by showing that the relation between primary and secondary designers and what they do in tandem is strongly determinant in redesigned new and useful decision support systems.

7 Acknowledgements

We want to thank our innovative students of the executive master of project and change management at Roskilde University for their willingness and help in providing empirical data for this project.

References

Aiken, M., Sheng, O.R.L., Vogel, D.R., 1991. Integrating Expert Systems With Group Decision Support Systems. *ACM Trans. Inf. Syst.* 9, 75–95.

Avison, D., Pries-Heje, J., 2008. Flexible Information Systems Development: Designing an Appropriate Methodology for Different Situations, in: *Proceedings of the International Conference on Enterprise Information Systems 2007*. pp. 212–224.

Baskerville, R., Ramesh, B., Levine, L., Pries-Heje, J., Slaughter, S., 2003. Is Internet-Speed Software Development Different ? *IEEE* 20, 70–77.

Boudreau, M.-C., Robey, D., 2005. Enacting Integrated Information Technology: A Human Agency Perspective. *Organ. Sci.* 16, 3–18. https://doi.org/10.1287/orsc.1040.0103

Bourque, P., Dupuis, R., Abran, A., Moore, J.W., Tripp, L., Wolff, S., 2002. Fundamental Principles of Software Engineering - A journey. *J. Syst. Softw.* 62, 59–70. https://doi.org/10.1016/S0164-1212(01)00136-4

Bygstad, B., Nielsen, P.A., 2012. Understanding and Managing Process Interaction, in: Wiberg M., C., Ågerfalk, P.J., Lundström, E. (Eds.), *Nordic Contributions in IS Research. SCIS 2012*. Springer, Berlin, Heidelberg, pp. 25–43.

Davern, B.Y.M.J., Wilkin, C.L., 2008. Evolving Innovations Through Design and Use. *Commun. ACM* 51, 133–137.

Fedorowicz, J., Gogan, J.L., 2010. Reinvention of Interorganizational Systems: A Case Analysis of the Diffusion of a Bio-terror Surveillance System. *Inf. Syst. Front.* 12, 81–95. https://doi.org/10.1007/s10796-009-9167-y

Fischer, G., Giaccardi, E., Ye, Y., Sutcliffe, A.G., Mehandjiev, N., 2004. Meta-Design: a Manifesto

for End-User Development. *Commun. ACM* 47, 33–38.
Germonprez, M., Hovorka, D., Collopy, F., 2007. A Theory of Tailorable Technology Design. *J. Assoc. Inf. Syst.* 8, 351–367.
Germonprez, M., Hovorka, D., Gal, U., 2011. Secondary Design : A Case of Behavioral Design. *J. Assoc. Inf. Syst.* 12, 662–683.
Gill, T.G., Hevner, A.R., Florida, S., 2013. A Fitness-Utility Model for Design Science Research. *ACM Trans. Manag. Inf. Syst.* 4, 1–24.
Gregor, S., 2006. The Nature of Theory in Information Systems of Theory in Information Systems. *MIS Q.* 30, 611–642.
Gregor, S., Hevner, A.R., 2013. Positioning and Presenting Design Science Research for Maximum Impact. *MIS Q.* 37, 337–355. https://doi.org/10.2753/MIS0742-1222240302
Gregor, S., Jones, D., 2007. The Anatomy of a Design Theory. *J. Assoc. Inf. Syst.* 8, 312–335. https://doi.org/Article
Heinrich, P., Schwabe, G., 2014. Communicating Nascent Design Theories on Innovative Information Systems through Multi-grounded Design Principles, in: *Proceedings of the 9th International Conference on Design Science Research in Information Systems. Lecture Notes in Computer Science*. pp. 148–163. https://doi.org/10.1007/978-3-319-06701-8_10
Hevner, A.R., March, S.T., Park, J., Ram, S., 2004. Design Science in Information Systems Research. *MIS Q.* 28, 75–105.
Jonathan Grudin, 1994. Groupware and Social Dymanics: Eight Challenges for. *Commun. ACM* 37, 93–105.
Kasper, G.M., 1996. A Theory of Decision Support System Design for User Calibration. *Inf. Syst. Res.* 7, 215–232. https://doi.org/10.1287/isre.7.2.215
Kuechler, W., Vaishnavi, V., 2012. A Framework for Theory Development in Design Science Research : Multiple Perspectives Science Research : Multiple Perspectives. *J. Assoc. Inf.* 13, 395–423.
Markus, M.L., Majchrzak, A., Gasser, L., 2002. A Design Theory for Systems That Support Emergent Knowledge Processes. *MIS Q.* 26, 179–212.
McGill, T.J., 2004. The Effect of End User Development on End User Success. *J. Organ. End User Comput.* 16, 41–58. https://doi.org/10.4018/joeuc.2004010103
Neumann, G., Sobernig, S., Aram, M., 2014. Evolutionary Business Information Systems. *Bus. Inf. Syst. Eng.* 6, 33–38. https://doi.org/10.1007/s12599-013-0305-1
Newman, M., Robey, D., 1992. A Social Process Model of User-Analyst Relationships. *MIS Q.* 16, 249. https://doi.org/10.2307/249578
Orlikowski, W.J., Hofman, J.. D., 1997. An Improvisational Model of Change Management: The Case of Groupware Technologies. *Sloan Manage. Rev.* 38, 11–21.
Rice, R.E., Rogers, E.M., 1980. Reinvention in the Innovation Process. *Sci. Commun.* 1, 499–514. https://doi.org/10.1177/107554708000100402
Richter, A., Riemer, K., 2013. Malleable end-user software. *Bus. Inf. Syst. Eng.* 5, 195–197. https://doi.org/10.1007/s12599-013-0260-x
Rogers, E.M., 2003. *Diffusion of Innovations*. Free Press.
Shim, J.P., Warkentin, M., Courtney, J.F., Power, D.J., Sharda, R., Carlsson, C., 2002. Past, Present, and Future of Decision Support Technology. *Decis. Support Syst.* 33, 111–126. https://doi.org/10.1016/S0167-9236(01)00139-7
Simon, H.A., 1977. *The new science of management decision*. Prentice-Hall.
Tyre, M.J., Orlikowski, W.J., 1994. Windows of Opportunity : Temporal Patterns of Technological Adaptation in Organizations. *Organ. Sci.* 5, 98–118.
Van de Ven, A.H., 2007. *Engaged Scholarship: a Guide for Organizational and Social Research*. Oxford University Press.
Walls, J.G., Widmeyer, G.R., El Sawy, O.A., 1992. Building an Information System Design Theory for Vigilant EIS. *Inf. Syst. Res.* 3, 36–59.
Yin, R.K., 2009. *Case Study Research: Design and Methods*. Sage Publications.