Rethinking care processes : does anybody have an idea?

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Rob J.B. Vanwersch

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PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Technische Universiteit Eindhoven, op gezag van de rector magnificus prof.dr.ir. F.P.T. Baaijens, voor een commissie aangewezen door het College voor Promoties, in het openbaar te verdedigen op maandag 30 mei 2016 om 16:00 uur

door

Rob Johannes Barbara Vanwersch

geboren te Heerlen

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Finally, special thanks go to my parents. I wish to thank them for their unconditional and endless support. The fact that they combine this with giving me complete freedom to pursue my own objectives in life has enabled me to enjoy (research) life to the fullest.

Rob Vanwersch
Eindhoven, 2016

Contents

1

Introduction

Chapter 1

Introduction

Healthcare organizations are increasingly facing pressure to cure more people with fewer resources while satisfying strict quality and safety regulations. The redesign of care processes has become one of the key mechanisms for coping with this challenge (Locock 2003; Vanhaecht et al. 2006; Van Lent et al. 2012). This is reflected in the widespread interest and uptake of related management philosophies by healthcare practitioners and academic researchers, such as Lean, Six Sigma, Clinical Pathways, Business Process Reengineering, and Continuous Improvement (Locock 2003; Vanhaecht et al. 2006; Van Lent et al. 2012).

Care processes often include several consultations, diagnostic tests, and treatment activities, as well as supporting steps, such as scheduling and medical order entry. Hence, in healthcare, administrative processes, which have been the target of many traditional process redesign initiatives, meet (patient-)logistic processes, which are often characterized by a highly complex and flexible interplay of different specialized organizational units (Mans et al. 2009; Mans et al. 2013). As such, the healthcare domain can be seen as a particularly interesting domain for process redesign.

A typical process redesign initiative consists of describing the as-is process, conducting an analysis of the as-is to identify process weaknesses, generating process improvement ideas (i.e. rethinking the process), and implementing the new process (Netjes 2010). Whereas much time is typically spent on describing and analyzing the as-is situation in a systematic way, process improvement ideas are often generated in one or a few workshops using a highly intuitive approach (Griesberger et al. 2011; Limam Mansar et al. 2009; Netjes et al. 2006). For example, starting from a set of process improvement goals and an analysis of the as-is process, employees merely brainstorm about process improvement ideas during workshop sessions (Limam Mansar et al. 2009). Often, these sessions are chaired by an external consultant who frequently raises the question *"Does anybody have an idea?"* Such a highly intuitive approach lacks any guidance with regard to the kind of process improvement ideas that need to be considered and does not provide a solution for the personal inertia to search for process improvement possibilities that are different from familiar directions (Chai et al. 2005). These limitations restrict the systematic exploration of the full range of process improvement possibilities. Consequently, redesign sessions are vulnerable to biased choices and may miss many attractive process improvement ideas (Chai et al. 2005; Gettys et al. 1987; Limam Mansar et al. 2009). In this way, the full potential of redesigning care processes is not achieved in terms of, for example, reducing costs and throughput times and improving patient satisfaction. This leads us to question: "*Does anybody have an idea regarding a better approach to rethinking care processes?*"

As argued by Recker and Rosemann (2014), method-ism that ensures a more complete and systematic exploration of the solution space might be highly beneficial for the creative act of generating process improvement ideas. However, whereas the systematic description and analysis of as-is processes has gained widespread interest from academic researchers and related reviews are available (e.g. Van der Aalst 2013), comprehensive methodological support is not available for the act of generating process improvement ideas (Chai et al. 2005; Griesberger et al. 2011; Netjes 2010; Valiris and Glykas 1999; Van der Aalst 2013; Zellner 2011). This implies that healthcare practitioners are not supported by a complete overview of the key choices to be made when faced with the task of deciding on a respective method. Nor do they have access to all the options available for each of these methodological decision areas, such as the different types of information that can be collected prior to rethinking care processes.

The absence of a categorized overview of existing methods does not imply that nobody has worked on a better method for rethinking care processes or processes in general. Nonetheless, given the plethora of management philosophies and related labels, existing attempts aimed at developing better methods are fragmented. This means that synergy opportunities between attempts of different management philosophy streams have largely remained unexplored. Consequently, there still is room to design a substantially improved method for rethinking care processes. Another limitation of existing attempts is that the evidence in favour of newly developed approaches is largely anecdotal in nature. Only a limited number of case studies are available that contain an evaluation of a newly developed method (e.g. Chai et al. 2005; Jansen-Vullers and Reijers 2005; Nissen 2000). These case studies, however, lack ways to compare the method's performance with the performance of competing methods, such as the highly intuitive brainstorm approach. This implies that benefits attributable to developed methods still are hard to determine.

Taking the above into account, raising the practical question "*Does anybody have an idea regarding a better approach to rethinking care processes?*" gives rise to several interesting research questions. These are outlined in the next section.

The remainder of this chapter is structured as follows. In Section 1.1, we present the research objective followed by the specific research questions. Moreover, we explain the research design, which outlines *what* we did to answer these questions. In Section 1.2, we discuss in more detail *how* we answered the research questions by providing an overview of the research methods applied. Section 1.3 concludes this chapter by presenting the outline of the remainder of this thesis.

1.1 Research objective and design

Based upon the problem statement described in the previous section, the main objective of this thesis is to build and evaluate a new method for rethinking care processes. In this way, we aim to answer the following main research question.

RQ: How to support the generation of process improvement ideas for care processes?

As discussed in the introduction section, the term *care processes* refers to processes in healthcare organizations that typically contain several consultations, diagnostic tests, treatments, as well as supporting steps, such a scheduling and medical order entry. The rethinking of these processes focuses on improving the orchestration of these different activities rather than on changing the way medical decisions are made based on medical knowledge and patient characteristics. In the terms of Lenz and Reichert (2007), organizational procedures instead of medical diagnostic-therapeutic cycles are the subject of investigation.

The main research question is decomposed into three research questions. Research question 1 (see box below) is answered in the first part of this thesis. By answering this research question, we gained insights into the status-quo regarding methodological support for rethinking care processes. This existing knowledge base supported us in positioning and grounding the development of a new method for rethinking care processes in the second part of this thesis. Furthermore, we made use of this knowledge base to construct a rigorous build and evaluation procedure for the new method. In the second part of this research project, we concentrated our efforts on building (see research question 2) and evaluating (see research question 3) the new method.

In the remainder of this section, we discuss the three research questions and the research design that was developed to answer these questions. We wish to note that research questions 2 and 3 were formulated after answering research question 1. The same holds for the development of the research design regarding research questions 2 and 3. Nonetheless, we decided to introduce all research questions and the complete research design in this introduction section. In this way, this section also serves as an advance organizer.

Part 1: Methodological support for rethinking care processes

RQ 1: What is the status-quo regarding methodological support for rethinking care processes?

RQ 1.1: *(a)* *What methods are available for rethinking care processes?*
(b) *What opportunities can be identified for improving these methods?*

RQ 1.2: *(a)* *What research procedures were followed to develop these methods?*
(b) *What lessons can be learned from these procedures?*

Research question 1 consists of research question 1.1 and research question 1.2, which both consist of two sub-questions. Below, we discuss the research design that was developed to answer research question 1.1 and 1.2.

Research question 1.1

In order to answer research question 1.1, we investigated available methods for rethinking care processes. More specifically, we identified six key choices to be made concerning a method for the act of generating process improvement ideas (see Figure 1.1):
(1) the *aim* that explains the objectives of the act;
(2) the human *actors* invited to participate;
(3) the *input* specifying the information that is collected prior to the act;
(4) the *output* describing the artifacts that are the result of the act;
(5) the *technique* that prescribes how to generate process improvement ideas;
(6) the *tool* defined as a software package that is able to support the act.

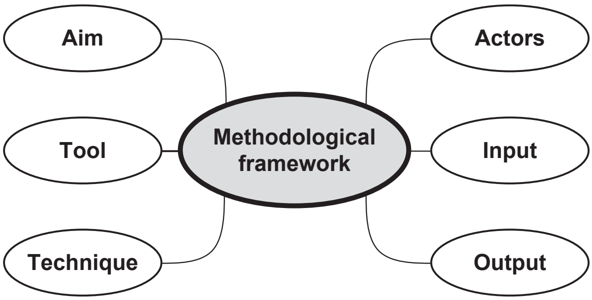


Figure 1.1. Overview of methodological decision areas.

For each of these six methodological decision areas, we identified the different method options available. A method option can be seen as a concrete type of objective, actor, or artifact that might be chosen in the context of composing a method. For example, a medical guideline is an example of an *input*-related method option that can be collected prior to the act of rethinking care processes. The overview of categorized method options resulted in a so-called methodological framework.

Expecting a scarcity of methods that were customized for the healthcare domain, we also reviewed application domain-independent methods and related success factors for generating process improvement ideas to develop this framework. Along these lines, we answered research question 1.1.a.

Based on a critical evaluation of the methodological framework, we observed several blind spots of existing methods and identified related improvement directions. In this way, we answered research question 1.1.b.

Research question 1.2

In addition to developing a comprehensive methodological framework, we also investigated the research procedures followed to develop methodological support for rethinking (care) processes. In particular, we analyzed the research methods used to build and evaluate methods for this act in order to answer research question 1.2.a. After a critical evaluation of these research procedures, we were able to identify several recommendations for building and evaluating new methods. In this way, we answered research question 1.2.b.

Part 2: The Rethinking of Processes (RePro) technique

RQ 2: What new technique can be developed to support a more complete exploration of process improvement possibilities for care processes?

RQ 3: How does the newly developed technique perform compared to traditional brainstorming?

After answering research question 1, we continued with building and evaluating a new method for rethinking care processes in the second part of this research project. Answering research question 1.1.a led to the identification of multiple research challenges requiring further investigation. Based on the expected improvement potential and available expertise in our research group, we concentrated our research efforts on one of these challenges in the second part of this research endeavor, i.e. building and evaluating a new *technique* for rethinking care processes. As such, one of the six methodological decisions areas was at the center of attention (see Figure 1.2).

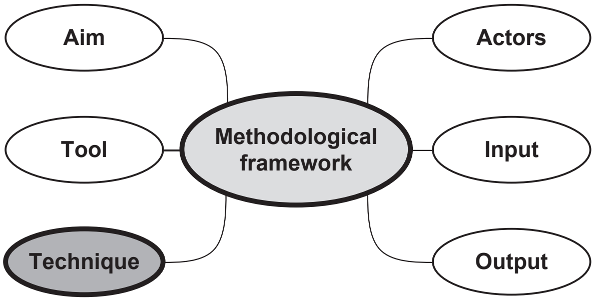


Figure 1.2. Focus on technique element in second part of thesis.

The focus on the technique element does not imply that we neglected the other methodological decision areas. For example, we specified the selected method options with regard to the other methodological decision areas when evaluating the technique. Moreover, we used the complete methodological framework when reasoning about further improvement directions for the technique. Nonetheless, building or evaluating new method options for one of the other methodological decision was outside the scope of this thesis.

Research question 2

Based on the identified blind spots of existing methods and related improvement directions, we built a new technique for rethinking care processes, i.e. the Rethinking of Processes (RePro) technique. The main objective of this technique is to support practitioners in a more complete exploration of the potential solution space as compared to traditional brainstorming. The latter technique is typically used to rethink care processes in practice. In order to achieve the main objective of the RePro technique, the RePro technique describes how to move from current process insights (as-is) to concrete improvement ideas (to-be). The RePro technique includes two components: (1) a set of process improvement principles providing concrete guidance regarding the kind of process improvement ideas that can be considered, and (2) an application procedure that supports healthcare practitioners in a systematic screening of the principles. The aforementioned practitioners can be either external or internal process analysts with an educational background in process management or senior healthcare professionals with a medical background.

After building a first version of the RePro technique, we improved its design by evaluating the core building blocks of each of the two components. Along these lines, we answered research question 2.

Research question 3

As a final step of this research endeavor, we evaluated the performance of the RePro technique. In particular, we compared the performance of the RePro technique with the performance of traditional brainstorming. As part of this evaluation, we defined and measured several outcome measures, such as the diversity and originality of the ideas generated. In this way, we answered research question 3.

1.2 Research methods applied

The research methods used to answer the three research questions are organized around two parts and five chapters. In Figure 1.3, we show the relationships between the parts, chapters, research questions, research methods applied, and related deliverables.

				Research methods	**Deliverables**
Part 1	Chapter 2	RQ 1	RQ 1.1 & RQ 1.2	Systematic literature review	Initial version methodological framework + Improvement directions for methods + Overview research procedures + Lessons learned regarding research procedures
	Chapter 3		RQ 1.1	Cross-case analysis + Field study consultancy firms	Enriched version methodological framework + Additional improvement directions for methods
Part 2	Chapter 4	RQ 2		Delphi procedure	Initial version RePro technique
	Chapter 5			Cross-case analysis + Applicability check with potential end-user groups	Improved version RePro technique
	Chapter 6	RQ 3		Lab experiments	Performance analysis RePro technique

Figure 1.3. Relationship between thesis parts, chapters, research questions, research methods applied, and related deliverables.

Part 1: Methodological support for rethinking care processes

As shown in Figure 1.3, the first part of this thesis contains two chapters that both address research question 1.

Research question 1.1

In order to answer research question 1.1, we started with the execution of a systematic literature review (e.g. Grimshaw et al. 2003). The results of this review are discussed in Chapter 2. The systematic literature review was conducted to develop an initial version of the methodological framework as described in the previous section. To this end, we extracted method options from numerous scientific studies in the information systems, management sciences, and health sciences domain. Based on a critical evaluation of the developed framework, we were able to identify several improvement directions for existing methods.

In spite of the review's comprehensive coverage, a limitation is that the studies used to create the framework mainly aimed at *developing* new *application domain-independent* methods for generating process improvement ideas. These methods developed in the scientific domain might be different from the methods applied in healthcare practice. Hence, we decided to enrich the framework with empirical insights from *applications* of methods *in healthcare*. This enrichment is explained in Chapter 3. By comparing the selected method options in practical applications with the ones in the framework, the completeness of the methodological framework was evaluated and additional improvement directions for methods were identified. Two complementary research methods were used for this purpose: a cross-case analysis (e.g. Larsson 1993; Lewis 1998) and a field study (e.g. Cooper and Schindler 2003; Dillman 2000). In the cross-case analysis, we reviewed existing case studies discussing an application of a method for rethinking care processes. In the field study, senior process consultants were interviewed about the methods that they have applied when rethinking care processes. As such, research question 1.1 is addressed by the systematic literature review in Chapter 2, as well as by the cross-case analysis and the field study among consultancy firms in Chapter 3.

Research question 1.2

To provide an answer to research question 1.2, we made use of the systematic literature review in Chapter 2. In particular, we investigated the research procedures followed by the scientific studies that were used to develop the initial version of the methodological framework. Based on a critical evaluation of these procedures, we outline several lessons learned in Chapter 2. These lessons learned include recommendations regarding how to build and evaluate new methods for rethinking care processes.

Part 2: The Rethinking of Processes (RePro) technique

The second part of this thesis contains three chapters that address research question 2 and 3. As graphically depicted in Figure 1.3, Chapter 4 and 5 address research question 2 and Chapter 6 provides an answer to research question 3.

Research question 2

As a first step towards answering research question 2, we built an initial version of the RePro technique. In Chapter 4, we present this initial version of the RePro technique and explain its building procedure. As part of the building procedure, we made use of the Delphi technique. The Delphi technique is a structured discussion technique that relies on a panel of people who have to reach consensus about a certain topic (Van de Ven and Delbecq 1974). This technique was used to develop the set of process improvement principles, i.e. the backbone of the RePro technique.

After building the initial version of the RePro technique, we evaluated its core building blocks to fine-tune its design. This evaluation and refinement of the RePro technique is discussed in Chapter 5. Two complementary research methods were used. Firstly, a cross-case analysis was executed. By analyzing improvement proposals in existing case studies, we were able to investigate the application potential of the set of process improvement principles. Secondly, we conducted an applicability check, which aims to evaluate and further improve a research artifact with support of practitioners (e.g. Rosemann and Vessey 2008). By means of conducting an applicability check with the two potential end-user groups, we were able to further fine-tune the set of RePro principles and the related application procedure.

Research question 3

In order to answer research question 3, we decided to conduct two lab experiments. Lab experiments enable a rigorous evaluation of an artifact (the RePro technique in this particular case) in a controlled setting (e.g. Cooper and Schindler 2003; Hevner et al. 2004). The two lab experiments are explained in Chapter 6. The basic set-up of the two experiments was identical. Both experiments aimed at comparing the performance of the RePro technique with traditional brainstorming. During both experiments, participants had to generate process improvement ideas for a care process. As a basis for idea generation, participants received a detailed, realistic case description. The main difference between the two experiments was the selected group of participants. Participants in the first experiment were 89 graduate students in Industrial Engineering at Ghent University. In the second experiment, 72 graduate students in Nursing & Midwifery at KU Leuven participated.

By defining, measuring, and evaluating different outcome measures, we were able to gain insights into the benefits of the RePro technique for two potential end-user groups.

1.3 Outline thesis

The remainder of this thesis is organized as follows:

Part 1: Methodological support for rethinking care processes

Chapter 2 describes the systematic literature review. By developing a comprehensive methodological framework, investigating research procedures of selected studies, and identifying related improvement directions, research questions 1.1 and 1.2 are addressed in this chapter. Chapter 2 is based on the following publications:

- Vanwersch, R.J.B., Shahzad, K., Vanderfeesten, I., Vanhaecht, K., Grefen, P., Pintelon,

L., Mendling, J., Van Merode, G.G., & Reijers, H.A. (2016). A critical review and framework of business process improvement methods. *Business & Information Systems Engineering*, *58*, 43-53.
- Vanwersch, R.J.B., Shahzad, K., Vanderfeesten, I., Vanhaecht, K., Grefen, P., Pintelon, L., Mendling, J., Van Merode, G.G., & Reijers, H.A. (2013). *Methodological support for business process redesign in healthcare: a systematic literature review* (Beta working paper no. 437). Eindhoven, NL: Eindhoven University of Technology.
- Vanwersch R.J.B., Shahzad, K., Vanhaecht, K., Grefen, P., Pintelon, L., Mendling, J., Van Merode, G.G., & Reijers, H.A. (2011). Methodological support for business process redesign in health care: a literature review protocol. *International Journal of Care Pathways, 15*, 119-126.

Chapter 3 discusses the enrichment of the methodological framework (as presented in Chapter 2) with empirical insights from method applications in healthcare. A cross-case analysis and field study among consultancy firms were conducted towards this end. In this way, we were able to answer research question 1.1.

Part 2: The Rethinking of Processes (RePro) technique

Chapter 4 presents the initial version of the RePro technique and explains its building procedure. As part of the building procedure, we made use of the Delphi technique. This study was the first step towards answering research question 2. This chapter is based on the following publication:
- Vanwersch R.J.B., Pufahl, L., Vanderfeesten, I., & Reijers, H.A. (2014). *The RePro technique: a new, systematic technique for rethinking care processes* (Beta working paper no. 465). Eindhoven, NL: Eindhoven University of Technology.

Chapter 5 describes the evaluation of the core building blocks of the RePro technique and the refinement of its design. In this chapter, we discuss the cross-case analysis and applicability check with potential end-users that were conducted to answer research question 2. This chapter is based on the following publication:
- Vanwersch, R.J.B., Pufahl, L., Vanderfeesten, I., Mendling, J., & Reijers, H.A. (2015a). *How suitable is the RePro technique for rethinking care processes?* (Beta working paper no. 468). Eindhoven, NL: Eindhoven University of Technology.

Chapter 6 discusses the evaluation of the performance of the RePro technique. Two lab experiments were executed to compare its performance with traditional brainstorming in a controlled setting. In this way, we were able to answer research question 3. Parts of the results in this chapter have been published as a conference paper:
- Vanwersch R.J.B., Vanderfeesten, I., Rietzschel, E., & Reijers, H.A. (2015b). Improving business processes: Does anybody have an idea? In H.R. Motahari-Nezhad, J. Recker, & M. Weidlich (Ed.), *Business Process Management*. Paper presented at the 13th International Conference on Business Process Management, Innsbruck, Aug 31 - Sep 3 2015 (pp. 3-18). Berlin, DE: Springer.

Chapter 7 is the concluding chapter of this thesis. It integrates the findings of both parts of this thesis. We answer all research questions and discuss the implications of our work. We end with the limitations of our work and several suggestions for future research.

Part 1

Methodological support for rethinking care processes

“Focus 90% of your time on solutions and only 10% of your time on problems.” (Anthony J. D’Angelo)

“We build too many walls and not enough bridges.” (Isaac Newton)

2

Methodological support for rethinking care processes: a framework and critical evaluation of the status-quo*

* **This chapter is based on:**

- Vanwersch, R.J.B., Shahzad, K., Vanderfeesten, I., Vanhaecht, K., Grefen, P., Pintelon, L., Mendling, J., Van Merode, G. G., & Reijers, H.A. (2016). A critical review and framework of business process improvement methods. *Business & Information Systems Engineering, 58*, 43-53.
- Vanwersch, R.J.B., Shahzad, K., Vanderfeesten, I., Vanhaecht, K., Grefen, P., Pintelon, L., Mendling, J., Van Merode, G. G., & Reijers, H.A. (2013). *Methodological support for business process redesign in healthcare: a systematic literature review* (Beta working paper no. 437). Eindhoven, NL: Eindhoven University of Technology.
- Vanwersch R.J.B., Shahzad, K., Vanhaecht, K., Grefen, P., Pintelon, L., Mendling, J., Van Merode, G.G., & Reijers, H.A.(2011). Methodological support for business process redesign in health care: a literature review protocol. *International Journal of Care Pathways, 15*, 119-126.

Chapter 2

Methodological support for rethinking care processes: a framework and critical evaluation of the status-quo

The redesign of care processes has a huge potential in terms of reducing costs and throughput times, as well as improving patient satisfaction. Despite considerable interest from academic researchers and healthcare practitioners in the redesign of these processes, comprehensive methodological support on how to move from current as-is process insights to to-be process alternatives is lacking. As such, no safeguard is provided to ensure a systematic exploration of the full range of process improvement possibilities during redesign initiatives in healthcare. Consequently, many attractive process improvement ideas remain unidentified and the improvement potential of many redesign initiatives is not fulfilled. In this chapter, we present the results of a systematic literature review. This review aims at establishing a rigorous and comprehensive methodological framework. This framework contains an overview of method options regarding the generation of process improvement ideas. This is established by identifying six key methodological decision areas, e.g. the human actors who can be invited to generate these ideas or the information that can be collected prior to this act. The methodological framework enables practitioners to compose a well-considered method to generate process improvement ideas based on the current status-quo. Based on a critical evaluation of the framework, we also offer recommendations that facilitate academic researchers to ground and improve methods for generating process improvement ideas. In addition to the methodological framework and its critical evaluation, this review investigates the research procedures of the studies that were used to create the framework. Related to this investigation, academic researchers can find guidance regarding procedures for building and evaluating new methods.

2.1 Introduction

Redesigning end-to-end care processes is challenging and requires comprehensive methodological support (O'Connor 2012). Unfortunately, this kind of support is not available for the act of generating process improvement ideas, i.e. for rethinking processes (Chai et al. 2005; Griesberger et al. 2011; Netjes 2010; Valiris and Glykas 1999; Van der Aalst 2013; Zellner 2011). This means that healthcare practitioners are not supported by a complete overview of the key choices to be made regarding a method for generating process improvement ideas. Nor do they have access to a complete list of options that might be chosen for each of these methodological decision areas, such as a list of the different types of information that can be collected prior to generating process improvement ideas. In the absence of this support, highly intuitive approaches have gained widespread use to generate process improvement ideas (Chai et al. 2005; Limam Mansar et al. 2009). Often, employees merely brainstorm about improvement ideas based on a set of process improvement goals and an analysis of the as-is process (Limam Mansar et al. 2009). Such sessions are at risk to lead to biased choices and to neglect attractive process improvement ideas (Chai et al. 2005; Limam Mansar et al. 2009). As such, many opportunities for reducing costs and throughput times, as well as for improving patient satisfaction are missed.

Existing research efforts that aim at providing methodological support for generating process improvement ideas have two limitations that inhibit them from providing comprehensive support. Firstly, these efforts typically do not cover all key choices to be made regarding a method for rethinking a process (Zellner 2011). For example, there are studies that mainly focus on developing a software package supporting the generation of process improvement ideas. In these studies, other but related methodological decisions areas are neglected, such as the different process stakeholders that have to participate in redesign sessions (e.g. Kim and Kim 1998; Lee and Pentland 2000; Lee et al. 2008). Secondly, we observe that existing research efforts are fragmented and performed in at least three different research domains, i.e. the information systems, management sciences, and health sciences domain. Screening classification systems of electronic search databases within each of these domains reveals that numerous management philosophies and related labels share an interest in the redesign of business processes. Within the information systems domain, labels such as “Business Process Reengineering”, “Business Process Improvement” and “Workflow Engineering” are used. Within the management sciences domain, “Lean”, “Six Sigma”, “Total Quality Management” and “Service Engineering” are well-known labels, while terms such as “Clinical Pathways” and “Care Pathways” have received considerable interest within the health sciences domain. Due to the lack of methodological coverage by individual research efforts and the fragmented nature of the field, a systematic literature review is called for in this cross-domain area to establish comprehensive methodological support for rethinking care processes

In this chapter, we describe a systematic literature review conducted to develop a comprehensive methodological framework for generating process improvement ideas in healthcare. We wish to point out that the scope of this review was not solely limited to methodological support that is fully customized for the healthcare domain. Expecting a scarcity of methods that are customized for this domain, we also reviewed application domain-independent methods and related success factors for generating process improvement ideas. The framework developed contains an overview of method options for six key methodological decision areas: aim, actors, input, output, technique, and tool (Alt et al. 2001; Brinkkemper 1996; Cossentino et al. 2006; Henderson-Sellers and Ralyté 2010; Kettinger et al. 1997; Reijers and Limam Mansar 2005; Zellner 2011). Screening this framework facilitates healthcare practitioners to compose a well-considered method for generating process improvement ideas based on method options offered by existing methods. Moreover, a critical evaluation of this framework resulted in recommendations that support academic researchers to ground and improve methods for generating process improvement ideas.

It should be emphasized that the framework is not (nor intended to be) directly applicable to generate process improvement ideas. Rather, it is the result of a review of the various existing methods and their success factors in generating process improvement ideas. The presented framework, due to its identification of important methodological decision areas and options for improvement methods, should be considered as solid and useful support to anyone composing or developing a new method for generating process improvement ideas in the healthcare domain. In summary, the framework gives meta-method insights.

In addition to the framework and its related recommendations, this review includes a critical evaluation of the research procedures of the studies that were used to create the framework (e.g. an analysis of applied research methods). Based on this evaluation, recommendations are offered that assist academic researchers in developing rigorous build and evaluation procedures for new methods.

This chapter is structured as follows. In Section 2.2, we position our methodological framework regarding two related recent taxonomies. Section 2.3 outlines our literature review methodology. Section 2.4 provides the results of our literature review. A discussion follows in Section 2.5, which includes recommendations regarding improvement directions for methods as well as advice with regard to the construction of rigorous build and evaluation procedures. Finally, we summarize this chapter in Section 2.6.

2.2 Related taxonomies

Our work enriches two Business Process Management (BPM) taxonomies that were recently developed: Van der Aalst's (2013) BPM use case classification, and Recker and Rosemann's (2014) Innovation thinking style matrix. Van der Aalst (2013) provides a set of twenty BPM use cases, with *process models* as fundamental concepts for analyzing, understanding, configuring, and improving business processes. This set contains, for example, the widely applied use case "Discover Model from Event Data". This use case refers to the automated generation of a process model based on event logs using process mining techniques. In our review, the act of generating process improvement ideas, instead of the process model, is at the center of attention. This does not mean that the concept of a process model is beyond the scope of our work. Process models and related data elements are potential inputs for and outputs of the act of generating process improvement ideas, such as illustrated in the BPM use case "Improve Model" (Van der Aalst 2013). These elements are, however, just one of the possible inputs and outputs. For example, process weaknesses as identified by customers are also considered as potential inputs in our review. Our review enriches Van der Aalst's (2013) review also in terms of the kind of aspects that are taken into account. His use cases mainly describe *aim*, *input*, *output* and *technique* aspects of BPM use cases. In this review, we also extensively discuss the kind of human *actors* who can be invited to generate process improvement ideas and the *tools* that can be used to support this act. As such, we provide a comprehensive overview of method options for generating process alternatives.

Recker and Rosemann (2014) provide a classification of different innovation thinking styles and methods, which can be used to innovate processes, products, and assets. Their matrix contains the following two axes: where you seek to innovate and how you identify potential innovations. The first axis distinguishes *operational assets and procedures* from *strategic assets and capabilities.* The second axis differentiates three innovation strategies:

understand yourself (e.g. by looking at your own processes)*, learn from others* (e.g. by making use of benchmark process insights), and *design* (e.g. by deriving process solutions from deep customer insights). Our review focuses on process innovation on an operational level and covers the lower segment of the matrix, i.e. the three different innovation strategies with regard to *operational procedures*. We extend Recker and Rosemann's (2014) work by elaborating on methods that are part of this segment of the matrix, i.e. by addressing the six key underlying methodological decision areas.

2.3 Research methodology

The systematic review outlined in this chapter consists of two parts:

(1) The first part targets studies that either developed a method for generating process improvement ideas (*method development studies*) or reviewed these methods (*method review studies*).

(2) The second part targets studies that investigated critical success factors of generating process improvement ideas *(success factor studies).*

Both parts provide input for the critical evaluations as well as for the methodological framework. For each part, we applied a separate search and screening procedure. In the remainder of this section, the general search, screening, extraction, and coding procedures are discussed and the search and selection procedure fragments that were customized for a part are explicitly indicated. An extended discussion of all procedures is available in (Vanwersch et al. 2013).

Search and selection

For each part, we started with an electronic database search to enable a comprehensive search (Fink 2010; Okoli and Schabram 2010; Randolph 2009; Rowley and Slack 2004). The electronic databases INSPEC, ABI/Inform, and Medline were selected to provide coverage of the information systems, management sciences, and health sciences domain. Synonyms, acronyms, and abbreviations related to the terms "process", "redesign", "method", and "factor" were systematically investigated and led to one extensive Boolean search expression for each part (see Appendix A.1). This Boolean expression was complemented with database-specific headings. Besides querying electronic databases, two relevant sources outside the scope of these search engines, i.e. the EPOC Cochrane database and the International Journal of Care Pathways, were manually scanned. As suggested by Rowley and Slack (2004) and Webster and Watson (2002), we decided to target only peer-reviewed journal articles and conference papers to identify high quality studies efficiently. In addition, only articles in English, containing an abstract, and published since 1990 were considered.

After running this primary search, we had to screen the identified articles. In line with recommendations of Brereton et al. (2007) and Webster and Watson (2002), two reviewers independently executed a two-stage relevance screening and a quality screening to select relevant and high quality studies for each part. Regarding each screening activity, inter-rater-agreement was assessed by means of the Kappa statistic (Fink 2010) and any disagreements between reviewers were resolved by consensus. The two-stage relevance screening included a title and abstract screening as well as a full copy screening. Several criteria used during the two-stage relevance screening applied to both parts of our literature review. For example, we evaluated for all included types of studies whether the study focused on generating *process improvement ideas*. Articles focusing on framing the process of interest, modeling or analyzing as-is processes, and / or implementing or evaluating process alternatives were excluded from further examination (e.g. Raisinghani et al. 2005). Other relevance criteria applied to only one part of our literature review. For instance, regarding the second part, we evaluated whether success factors could be translated to concrete method options for generating process improvement ideas. Articles that only discussed highly abstract success factors (e.g. improving the quality culture) were excluded from further examination (e.g. Talib et al. 2010). The quality screening was conducted for the full copies that passed the two-stage relevance screening. As part of this screening, we excluded, for example, method development studies that solely relied on expert opinion to develop a method (e.g. Furey 1993). For each part of our literature review, an overview of all inclusion and exclusion criteria can be found in Appendix A.2.

As proposed by Fink (2010) and Levy and Ellis (2006), two additional search strategies were used for each part after the primary search and screening procedure. Firstly, a secondary search was conducted to identify additional studies by means of backward and forward tracing of references. Secondly, we contacted an advisory committee consisting of six senior researchers together covering the information systems, management sciences, and health sciences domain. These members assessed the completeness of the primary and secondary search and recommended additional literature to further ascertain that important studies did not remain unidentified. For both strategies, which also targeted technical reports and book chapters, the full copies of the papers were screened similarly to the full copy screening procedures of the primary search.

Data extraction and coding

All identified and selected studies entered the data extraction and coding phase, which was identical for both parts. A detailed data extraction form (see Appendix A.3) was used to extract data fragments from these studies in line with recommendations of Brereton et al. (2007), Fink (2010), Kitchenham (2004), Okoli and Schabram (2010), Randolph (2009), and Webster and Watson (2002). Based on Method Engineering research (Brinkkemper 1996; Cossentino et al. 2006; Henderson-Sellers and Ralyté 2010) and related research in the field of business process redesign (Alt et al. 2001; Kettinger et al. 1997; Reijers and Limam Mansar 2005; Zellner 2011), we decided to extract data with regard to six key methodological decision areas. More detailed information regarding the identification of these decision areas can be found in (Vanwersch et al. 2013). The identified six methodological decision areas, i.e. *method elements*, with respect to the act of generating process improvement ideas are:
(1) the *aim* that explains the objective of the act;
(2) the human *actors* invited to participate;
(3) the *input* specifying the information that is collected prior to the act;
(4) the *output* describing the artifacts that are the result of the act;
(5) the *technique* that prescribes how to generate process improvement ideas;
(6) the *tool* defined as a software package that is able to support the act.

Additionally, we extracted two data elements regarding the research procedures that were adopted by the authors of the studies. These so-called *research procedure elements* are:
(1) the *label* used by the authors to refer to the redesign of business processes;
(2) the *study design* summarizing the research method types used.

In line with the grounded theory approach (Wolfswinkel et al. 2013), all data fragments were extracted and coded in an iterative fashion by making use of a structured procedure. One reviewer extracted data from all studies and assigned an initial code to each data fragment, using terms taken directly from the articles whenever available. A second reviewer independently extracted and coded data for a 10% random sample of the studies. Subsequently, data extraction and coding discrepancies were discussed in detail by both reviewers and resolved by consensus. In line with review recommendations (Brereton et al. 2007), an extractor-checker construction was used to efficiently extract and code data from the remaining studies. After this data extraction and initial coding step, the relationships between the initial codings were analyzed in more detail by both reviewers. This axial coding step (Wolfswinkel et al. 2013) resulted in updated concepts and categories.

2.4 Results

In this section, we outline the results of our literature review. Firstly, we discuss the search and selection results. Secondly, we present the data extraction and coding results with regard to the *research procedure elements*. Third and finally, we outline the data extraction and coding results regarding the *method elements*.

Search and selection results

The search and selection results of both literature review parts are graphically summarized in Figure 2.1.

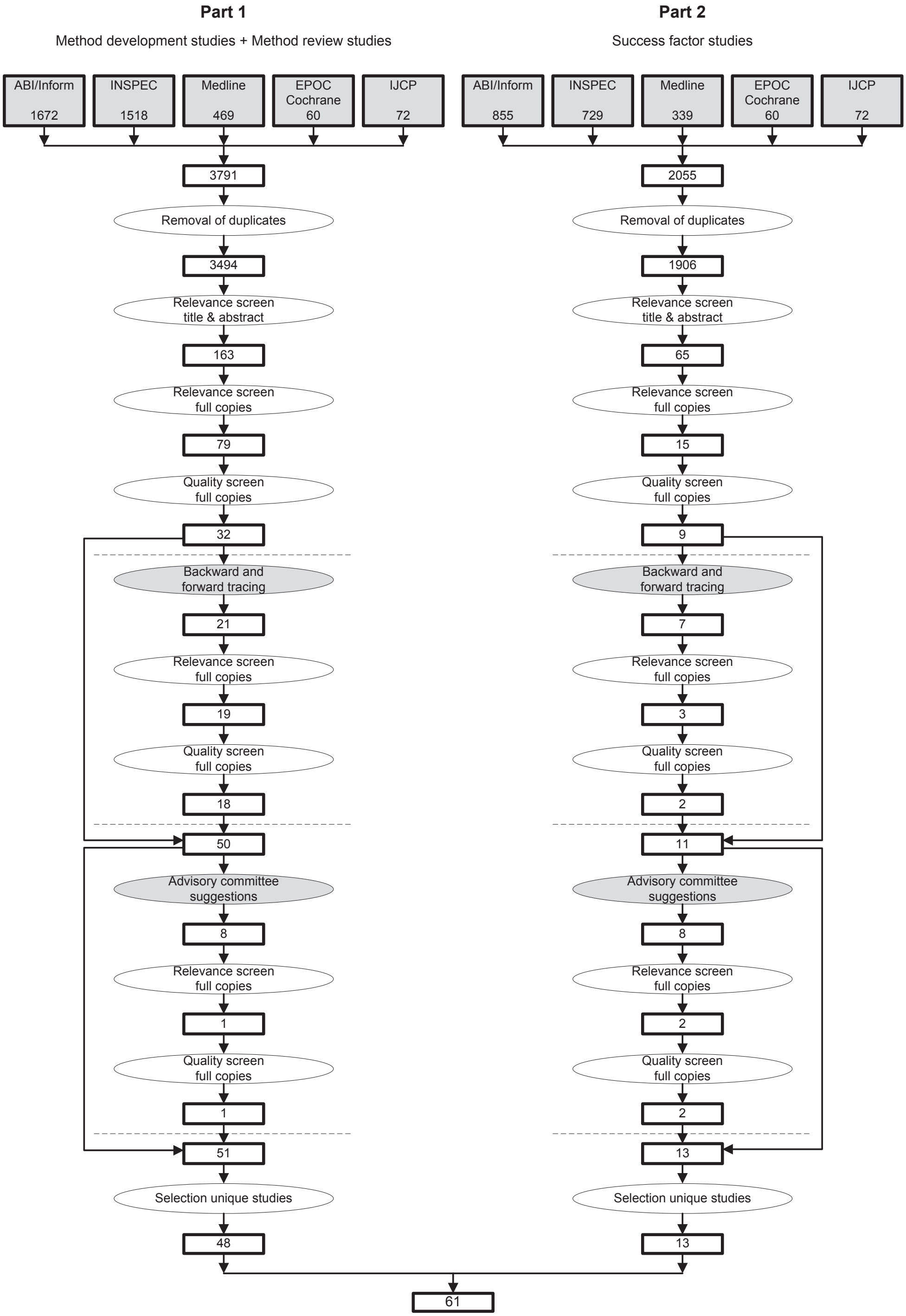


Figure 2.1. Flowchart search and selection results.

Regarding the first part, 3791 matching articles were obtained by means of the primary search. Of these, 32 passed the removal of duplicates, two-stage relevance screening, and quality screening. Based on these 32 articles, we identified 21 additional studies by means of backward and forward tracing of references. 18 out of these 21 studies passed the related assessment. Subsequently, the advisory committee suggested eight additional articles. Of these, one study passed the related evaluation. A further examination of the 51 (32 + 18 + 1) reports revealed that two articles could be excluded because these reports were predecessors of other articles and did not contain any new information. Furthermore, one article was an appendix that we decided to merge with the main publication that was also selected for inclusion. Hence, the first part contains 48 unique studies.

Regarding the second part, 2055 matching articles were obtained by means of the primary search. Here, nine articles passed the removal of duplicates, two-stage relevance screening, and quality screening. By means of backward and forward tracing of references, seven additional studies were identified. Of these, two passed the related assessment. In addition, two out of eight studies suggested by the advisory committee passed our screening. In summary, the second part contains 13 (9 + 2 + 2) unique studies. In total, 61 unique studies entered the data extraction and coding phase

For all relevance and quality screening activities, inter-rater-agreement, as determined by Kappa statistics, varies between substantial (min Kappa = 0.63) and perfect agreement (max Kappa = 1.00). An extended discussion of the search and screening results is available in (Vanwersch et al. 2013).

Data extraction and coding results: research procedure elements

An analysis of the sources of the 61 selected articles reveals that our set consists of 42 journal papers (69%), 17 conference papers (28%), one technical report (1.5%), and one book chapter (1.5%).

As shown in Table 2.1, 15 different *labels* were used by the authors of these studies to refer to the redesign of business processes. Business Process Reengineering (30%), Business Process Redesign (21%), Business Process Improvement (8%), and New Service Development (5%) are the most popular labels assigned.

Label	*No. of studies part 1*	*No. of studies part 2*	*No. of studies part 1+2*
Business Process Reengineering	10	8	18
Business Process Redesign	13	0	13
Business Process Improvement	5	0	5
New Service Development	3	0	3
Business Process Change	1	1	2
Service Engineering	2	0	2
Clinical pathways	0	2	2
Business Re-engineering	1	0	1
Process Life Cycle Engineering	1	0	1
Workflow Reengineering	1	0	1
Lean Six Sigma	1	0	1
Service Design	1	0	1
Service Innovation	1	0	1
Total Quality Management	0	1	1
Care pathways	0	1	1
No label	8	0	8
Total	48	13	61

Table 2.1. Study labels.

Table 2.2 summarizes the analysis of the *study designs* of the studies included.

	Research method type	*No. of studies**	*No. of studies explaining DCAS***
Part 1			
Method development studies (N=45)			
	Literature review (build)	45	0
	Field study (build)	1	0
	Case study (evaluation)	23	11
	Formal analysis (evaluation)	1	-
	Illustration (evaluation)	10	-
Method review studies (N=3)			
	Literature review	3	3
	Field study	1	1
	Lab study	1	1
Part 2			
Success factor studies (N=13)			
	Literature review	12	3
	Case study	4	4
	Field survey	6	6
	Field study	1	1

Table 2.2. Study designs. *Each study may involve multiple research method types; **DCAS = Data collection and analysis strategy.

Our set of studies contains three types of studies as explained in the research methodology section: 45 *method development studies*, 3 *method review studies* and 13 *success factor studies*. With regard to *method development studies*, design science researchers distinguish a build and an evaluation phase (Hevner et al. 2004; March and Smith 1995). Regarding the build phase of method development studies, a further examination of the study designs reveals that the researchers rarely have used research method types other than literature reviews to support the construction of new methods for rethinking processes. After finalizing the build phase, case studies (51%) and illustrations (22%) have been frequently used by researchers during the evaluation phase. Interestingly, none of the literature reviews and less than half of the case studies (48%) of the *method development studies* include a discussion of data collection and analysis strategies. Among *method review* and *success factor studies*, literature reviews (94%) and field surveys (38%) dominate. Again, only a minority of the literature reviews of these study types (40%) includes an explanation of data collection and analysis strategies.

Regarding the research procedure elements, a detailed overview of all codings per study is available in (Vanwersch et al. 2013).

Data extraction and coding results: method elements

As discussed in the research methodology section, we decided to extract and code data fragments regarding six methodological decision areas, i.e. six method elements. As shown in Table 2.3, the *input* element is most frequently addressed in our set of 61 studies (93%). The decision areas *aim* (79%), *output* (74%), *technique* (71%), *actors* (64%) and *tool* (51%) follow suit: these are still discussed in a majority of the reports.

Method element	*No. of studies part 1*	*No. of studies part 2*	*No. of studies part 1+2*
Input	45	12	57
Aim	36	12	48
Output	43	2	45
Technique	42	1	43
Actors	26	13	39
Tool	29	2	31

Table 2.3. Method elements.

The extraction and coding procedure resulted in an overview of method options per method element and per study. As discussed in the research methodology section, method option names were taken directly from the articles whenever possible. However, if several initial codings had an identical meaning, these codings were merged. For example, the *external quality* option includes among others the following initial codings: patient satisfaction, patient perceptions of quality, and patient complaints. An overview of all coded method options per study is available in (Vanwersch et al. 2013). The coding results with regard to two studies are shown in Table 2.4 (Corbitt et al. 2000; Nissen 2000).

Method element	*Corbitt et al. (2000)*	*Nissen (2000)*
Aim	Costs Revenue Quality	Costs Time
Actors	Process actors	Process actors Management
Input	Customer needs Process model Problem investigation	Process model Process measures
Output	Summary redesign proposals Textual process descriptions Process models Force-field-analyses	Summary redesign proposals Simulation models Impact analyses
Technique	Nominal group technique	Rule-based
Tool	Communication Voting Modeling Repository	Simulation Specific

Table 2.4. Method options per study.

The method introduced by Corbitt et al. (2000) heavily relies on the use of Group Decision Support Software (GDSS). This software allows for parallel and anonymous *communication* in a computer-mediated electronic environment, for *voting* on generated ideas, and for *modeling* to-be processes. The GDSS also includes *repository* functionality in the sense that all group's discussions can be stored. The method proposed by Corbitt et al. (2000) includes four steps to improve the performance of a process in terms of productivity (i.e. the *revenue / costs* ratio) and *quality.* All these steps are supported by the GDSS. As part of the first step, *process actors* are invited to share information with regard to *customer needs*, problems with the current process (i.e. *problem investigations*)*,* and initial (graphical) descriptions of the current process (i.e. *process models).* In the subsequent steps, improvement ideas are generated, discussed, and evaluated and ranked. As such, the procedure resembles the *nominal group technique*, which is characterized by individual idea generation followed by discussion and voting (Kettinger et al. 1997). Throughout all steps, improvement ideas and related discussions are stored (i.e. *summary redesign proposals*). The end deliverables of the procedure are a narrative of the to-be process (i.e. *textual process description*), a to-be *process model*, and a *force-field-analysis*. The latter is based on an identification and weighting of the forces that drive or restrain different groups of actors to implement changes.

The key premise of the method proposed by Nissen (2000) is that a limited set of *process measures* (e.g. the degree to which process activities are executed in parallel) can be used to identify pathologies (e.g. sequential process flow) in a given *process model*. These process pathologies can in turn be matched to redesign transformations, which offer generic guidance regarding how to solve the pathologies of the process under study (e.g. process delinearization). Based on the suggested redesign transformations by this *rule-based technique*, *process actors* are able to generate specific solutions for the pathologies and to discuss these with *management*. The discussed solutions (i.e. *summary redesign proposals*) can be translated to changes in a *simulation model*, which allows for the dynamic modeling of the to-be process and supports practitioners in validating and evaluating process alternatives on *costs* and *time*-related criteria (i.e. *impact analyses)*.

After the identification of the method options per study, we classified the total set of identified method options into (sub)-categories by looking at the underlying concepts of the method options. For example, the inputs *textual process description*, *process model* and *simulation model* share the concept of “specifying an AS-IS process”. Hence, we assigned all these method options to the category “*AS-IS process specification*”. This so-called axial coding step resulted in a comprehensive methodological framework containing an overview of categorized method options per method element.

Figure 2.2 provides a graphical, high-level summary of the methodological framework. In the remainder of this section, the method options that are part of the framework are briefly explained. An overview of the number of studies mentioning a certain method option can be found in Appendix A.4.

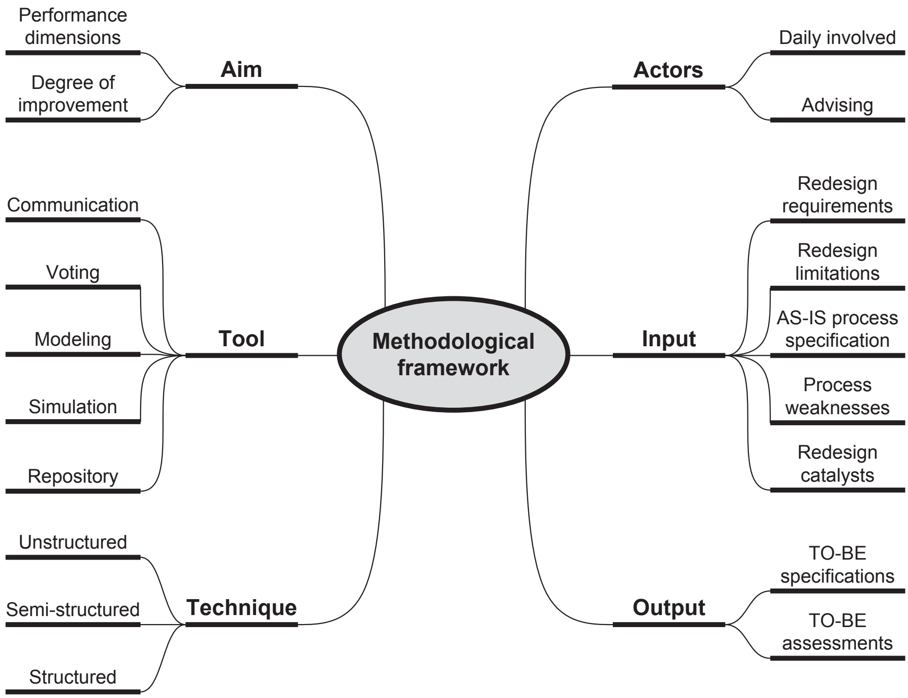


Figure 2.2. Graphical summary methodological framework.

Aim

The aim element outlines the objective of the act of generating process improvement ideas. An overview of potential objectives assists practitioners in selecting an aim that is aligned with the vision and strategy of the involved organizations. Two aim aspects can be distinguished:

- *Performance dimensions,* which delineate the kind of performance measures that need improvement, such as *costs*, *time* and *external quality*.
- *Degree of improvement,* which addresses whether *incremental* or *radical* improvements are needed.

Table 2.5 provides an overview of all identified aim options and related definitions.

Method option	*Definition*
Performance dimensions:	
Revenue	The income that is received from the sales of goods or services that are created by the process.
Costs	The value of money that has been used to produce goods or services that are created by the process.
Time	A measure of durations of events or intervals between them.
External quality	The quality of products or services as perceived by customers.
Internal quality	The quality of work as perceived by process actors.
Flexibility	The ability of the process to react to changes (Jansen-Vullers et al 2008).
Degree of improvement :	
Radical improvement	The aim is to achieve dramatic improvement gains by often challenging the organizational framework and applying new technology (Glykas and Valiris 1999).
Incremental improvement	The aim is to make some small changes to an existing process by typically eliminating non-value-added activities (Glykas and Valiris 1999).

Table 2.5. Aim related definitions.

Actors

The selection of human actors who have to participate in redesign sessions is another important methodological decision area. An overview of actors supports practitioners in composing a redesign team that is able to generate a variety of effective process improvement ideas and enables a smooth course of implementation. We identified two groups of actors:

- *Daily involved actors,* who are involved in either executing tasks within the process under study, i.e. so-called *process actors*, or in managing the process, i.e. *management*.
- *Advising actors,* who do not have any responsibility for the process under study, but are able to contribute to the development of process alternatives due to their expertise or experience. Examples of advising actors are *external consultants* and *patients*.

An overview of all identified actors and related definitions is provided in Table 2.6.

Method option	*Definition*
Daily involved:	
Process actor	Actor who is involved in executing tasks within the process.
Management	Actor who is involved in managing the process.
Advising:	
BPR specialist	Supporting staff specialist who has specific expertise in redesigning business processes.
Finance specialist	Supporting staff specialist who is knowledgeable about financial issues.
HR specialist	Supporting staff specialist who is knowledgeable about human resource management.
IS specialist	Supporting staff specialist who has specific expertise in designing information systems.
Marketing specialist	Supporting staff specialist who has specific expertise in communicating the value of a product or service to customers.
Customer / patient	Recipient of the products or services that are provided by the process.
Supplier	Actor who supplies goods or services that are used by the process.
External consultant	Actor who is employed externally (not a member of the firms where the process actors are employed) and provides professional advice on a temporary basis.
Peer	Actor who is employed internally or externally and is actively involved in a non-competing similar process.

Table 2.6. Actors related definitions.

Input

Prior to generating improvement ideas, it is important to collect useful information regarding the process under study. An overall picture of input options prevents one to neglect interesting information that enables the generation of effective process improvement ideas. Our analysis reveals that five input categories can be distinguished:

- *Redesign requirements*, which delineate the redesign objectives that need to be achieved in terms of *process output goals* or *stakeholder / patient needs*.
- *Redesign limitations*, which outline the factors that restrict the solution space, i.e. *constraints*, or influence it, i.e. *risks*.
- *As-is process specification*, which provides a description of the current process, such as a *process model* or *simulation model.*
- *Process weaknesses*, which identify redesign priorities, such as *process output measures* and *problem investigations*.
- *Redesign catalysts*, which provide inspiration for the creation of effective process alternatives, such as *benchmark process insights* and *technology developments*.

Table 2.7 provides an overview of all identified inputs and related definitions.

Method option	*Definition*
Redesign requirements:	
Process output goals	Desired end results of the redesign project in terms of process performance dimensions, e.g. the average access time of coronary artery bypass patients needs to be reduced with 60%.
Stakeholder / patient needs	Requirements that need to be fulfilled by the process according to patients or other process stakeholders.
Redesign limitations:	
Constraints	Restrictions that delineate the kind of process alternatives that are not going to be considered.
Risks	Factors that challenge the redesign of the process and might restrict the kind of process alternatives that are going to be considered (Limam Mansar et al. 2009).
AS-IS process specification:	
Textual process description	Textual description of the AS-IS process.
Process model	Model that provides a graphical representation of the AS-IS process (Kettinger et al. 1997).
Simulation model	Model that allows for the dynamic modeling of the AS-IS process (Kettinger et al. 1997).
Process weaknesses:	
Process output measures	Measures that are related to the process performance dimensions.
Process measures	Measures that provide a global view on the characteristics of the process, such as the degree of automation or parallelism (Netjes et al. 2008).
Different opinions regarding AS-IS process specification	Points of disagreement about how the AS-IS process works. Typically, these points of disagreement become apparent during process mapping activities (Bitner et al. 2008).
Problem investigation	Investigation which offers information regarding problems as perceived by the different process stakeholders.
Culture scan	Assessment of the shared values and beliefs of process stakeholders (Kettinger et al. 1997).
Redesign catalysts:	
Medical guidelines / key interventions	Documents with the aim of guiding decisions and criteria regarding diagnosis, management, and treatment in specific areas of healthcare. Typically, they are based on an examination of current evidence in the paradigm of evidence-based management (Vanhaecht et al. 2009).
Previous solutions	Solutions that have been suggested for problems that are related to the problems associated with the process under study (Chai et al. 2005; Lin and Su 2007; Su et al. 2008).
Benchmark process insights	Insights gained from comparing one's process with a similar process (Rohleder and Silver 1997; Talib and Rahman 2010).
Benchmark process models	Process models of a similar process (Bitner et al. 2008).
Technology developments	Insights gained from technology observing research (Hsiao and Yang 2010).
Industry value net	Overview of suitable partners with which the process under study could be integrated (Hsiao and Yang 2010).

Table 2.7. Input related definitions.

Output

The output element describes the artifacts that are the result of redesign sessions. An overview of possible outputs assists practitioners in selecting an effective way of communicating the results of redesign workshops. We identified two output categories:

- *To-be specifications,* which provide descriptions of process improvement ideas. *To-be service concepts*, *to-be process models*, and *to-be exception-handlers* are examples of options that explain the to-be process at different levels of abstraction.
- *To-be assessments,* which include preliminary evaluations of process alternatives, such as *impact analyses* and *force-field-analyses*.

An overview of all identified outputs and related definitions is provided in Table 2.8.

Method option	*Definition*
TO-BE specifications:	
TO-BE service concepts	Concepts that provide a description of the benefits that the process is expected to offer to the customers and determine the value proposition in the broader context of the value network within which it is embedded. As such, TO-BE service concepts are able to guide the design of TO-BE process specifications (Patrício et al. 2011).
Summary redesign proposals	Summary that provides a brief description of process improvement ideas, i.e. changes with regard to the AS-IS process that are worth further investigation.
Textual process descriptions	Textual descriptions of TO-BE processes.
Process models	Models that provide graphical representation s of TO-BE processes (Kettinger et al. 1997).
Simulation models	Models that allow for the dynamic modeling of TO-BE processes and support practitioners in validating and evaluating process alternatives (Kettinger et al. 1997).
TO-BE exception handlers	Handlers that describe ways to anticipate, avoid, detect, and resolve process exceptions (Klein and Dellarocas 2003).
TO-BE assessments :	
Impact analyses	Analyses that provide insights into the potential performance improvement impact and feasibility of process improvement ideas (Jansen-Vullers and Reijers 2005).
Force-field-analyses	Analyses that provide insights into the forces that either drive or restrain the implementation of process alternatives (Corbitt and Wright 1997; Corbitt et al. 2000; Kettinger et al. 1997).

Table 2.8. Output related definitions.

Technique

A technique prescribes how to generate process improvement ideas. An overview of techniques helps practitioners in choosing a well-considered way of generating these ideas. Three technique categories can be distinguished:

- *Unstructured* techniques, which are creativity techniques that do not contain a detailed procedure that specifies how to move from current process insights (as-is) to concrete improvement ideas (to-be) and do not provide guidance regarding the kind of process alternatives that need to be considered. *Brainstorming* and *out-of-the-box thinking* are examples of these techniques.
- *Semi-structured* techniques, which offer a work procedure that specifies how to move from current process insights (as-is) to concrete improvement ideas (to-be), but lack any guidance regarding the kind of process alternatives that need to be considered. Examples of these techniques are the *nominal group* and *multi-level design* technique.
- *Structured* techniques, which offer a work procedure that specifies how to move from current process insights (as-is) to concrete improvement ideas (to-be) and include guidance regarding the kind of process alternatives that need to be considered. *Rule-based* and *repository-based* techniques are instances of these techniques.

Table 2.9 provides an overview of all identified techniques and related definitions.

Method option	Definition
Unstructured :	
Brainstorming	Creativity technique that provides room for spontaneous generation of ideas by redesign participants, where creative thinking is stimulated through a process of adding on the other's concepts (Dennis et al. 2003; Kettinger et al. 1997).
Out-of-the-box thinking	Creativity technique that stimulates redesign participants to stretch redesign goals and reconsider assumptions underlying current process execution (Dennis et al. 2003; Kettinger et al. 1997).
Visioning	Creativity technique that encourages redesign participants to develop images of possible future processes by identifying and progressively breaking sacred cow assumptions or unsubstantiated constraints (Dennis et al. 2003; Kettinger et al. 1997).
Semi-structured:	
Delphi	Technique that distributes a sequence of anonymous questionnaires to redesign participants to successively refine their opinions and finally reach consensus (Kettinger et al. 1997).
Nominal group	Technique that offers a procedure for reaching group consensus through anonymous idea generation by individual redesign participants, followed by discussion and voting (Kettinger et al. 1997).
Multi-level design	Technique that starts with designing the to-be situation at a relatively high level of abstraction, i.e. the to-be service concept. After completion, two lower levels of abstraction, which together specify the to-be process, are successively considered (Patrício et al. 2011).
Grammar-based	Technique that captures the grammar underlying a business process and makes use of lexicon and rewrite rules to systematically explore process alternatives (Lee et al. 2008; Lee and Pentland 2000).
Structured :	
Rule-based	Technique that makes use of generic process redesign rules that have accumulated in literature or practice to develop process alternatives (Chai et al. 2005; Nissen 2000; Reijers and Limam Mansar 2005). The premise of these techniques is that specific process problems can be translated to generic process problems, for which generic process redesign rules can offer generic process solutions (Jansen-Vullers and Reijers 2005; Lin and Su 2007; Nissen 2000). An example of a generic process redesign rule is the parallelism rule, which states that redesign participants should consider executing tasks in parallel instead of executing them sequentially (Reijers and Limam Mansar 2005). As a final step, the generic process solutions have to be translated to specific process solutions (Jansen-Vullers and Reijers 2005; Lin and Su 2007; Nissen 2000).
Case-based	Technique that enables an efficient identification of earlier business process redesign projects. These projects offer guidance regarding the process alternatives that can be considered (Limam Mansar et al. 2003). These techniques make use of libraries of well-document previous business process redesign projects (Limam Mansar et al. 2009; Limam Mansar et al. 2003; Nissen 2000).
Repository-based	Technique that makes use of the notions of process specializations, coordination mechanisms and process exception handlers to systematically generate process alternatives on the basis of an identified list of core activities of the process under study and a repository (Bernstein et al. 1999; Klein and Petti 2006; Malone et al. 1999; Margherita et al. 2007). The repository that is used as a basis includes and organizes numerous specifications of existing processes (Bernstein et al. 1999; Klein and Petti 2006; Malone et al. 1999; Margherita et al. 2007).

Table 2.9. Technique related definitions.

Tool

A tool is defined as a software package that is able to support the generation of process improvement ideas. An overview of these can support practitioners in choosing tools that are able to increase the efficiency and effectiveness of the generation of process improvement ideas. Six tool functionalities were identified:

- *Communication* functionality, which enables large groups to communicate face-to-face or distributed in a computer-mediated electronic environment. Typically, this environment allows for parallel and anonymous input (Albano et al. 2001; Corbitt et al. 2000; Piirainen et al. 2009).
- *Voting* functionality, which allows participants to rate different process alternatives (Corbitt and Wright 1997; Mouro et al. 1999).
- *Modeling* functionality, which supports practitioners in creating graphical representations of process alternatives (Albano et al. 2001; Netjes et al. 2008; Thong et al. 2003).
- *Simulation* functionality, which allows dynamic modeling of business processes and supports practitioners in validating and evaluating process alternatives (Kettinger et al.

1997; Nissen 2000).

- *Repository* functionality, which provides support for the storage and retrieval of descriptions of process improvement ideas and related discussions (Albano et al. 2001; Mouro et al. 1999; Valiris and Glykas 1999).

2.5 Discussion

In this section, we discuss the main findings with regard to the research procedure elements as well as the method elements. Moreover, we outline the limitations of our literature review.

Discussion of research procedure elements

Our analysis of the research procedures of the selected studies leads to four observations. Firstly, we observe that authors have used a wide variety of labels to refer to the redesign of business processes. This observation does not only reinforce the need for a systematic review that carefully selects its search terms. More generally, it implies that academic researchers focused on one or a limited number of management philosophies are at risk to overlook valuable literature. For example, the literature reviews of Zellner (2011) and Mazzocato et al. (2010), which limited their attention to "Business Process Improvement" and "Lean" related terms respectively, do not cover any of the structured process redesign techniques. In particular, rule-based, case-based, and repository-based techniques are not identified by these studies. Therefore, researchers who want to gain insights into the state-of-the-art of methodological support for generating process improvement ideas in healthcare are recommended to explore a broad spectrum of labels.

Secondly, the analysis of labels reveals that labels that have gained widespread interest in practice and science, i.e. Clinical / Care pathways, Lean, and Continuous Improvement (Van Lent et al. 2012; Yasin et al. 2002) are not often used in our set of studies. Knowing that our list of search terms includes these three labels, this finding suggests that advocates of these management philosophies have devoted limited attention to developing methodological support for the act of generating process improvement ideas. Hence, we especially expect these advocates to gain additional insights regarding this act when broadening their field of interest to related research inspired by different management philosophies.

Thirdly, the analysis of study designs reveals that method development studies do not contain a wide variety of research method types. With respect to the build phase of method development, researchers have typically limited their attention to literature reviews, whereas other research method types are worth considering, such as field studies that elicit the specific requirements which the new method needs to fulfill. Also, with regard to the evaluation phase, other research method types may be alternatives of interest. Many method development studies either do not include an evaluation mechanism or merely provide an illustration of how the method can be applied. Only a small majority of studies includes a case study investigating the application of the method in practice. These case studies evaluate a method without comparing its performance with an already existing method. Lab or field experiments offer opportunities to compare the performance of different method options, such as different techniques, in a controlled environment (Hevner et al. 2004; Zelkowitz and Wallace 1998) and are worth further examination. In summary, researchers are invited to consider different but complementary research method types to allow for a step forward in facilitating evidence-based choices between different method options.

Fourth and finally, we observe that method development studies lack information regarding data collection and analysis strategies. In such studies, it is reasonable to expect information to be present regarding evaluation metrics and subject groups involved in evaluating business process redesign methods (Davidoff et al. 2008; Hevner et al. 2004; March and Smith 1995). Remarkably, only a minority of method development studies includes this kind of information. Therefore, we advice researchers to improve the explanation of data collection and analysis strategies in order to facilitate learning from method build and evaluation procedures. This improved explanation will also make method limitations more transparent and, consequently, will enable further method development that is geared towards resolving these limitations.

Discussion of method elements

An examination of the methodological framework (see Appendix A.4 for all details) reveals that many method choices can and have to be made regarding the act of generating process improvement ideas. Hence, we expect that the explicit examination of this comprehensive framework can support healthcare practitioners in making well-considered method choices. Therefore, we invite practitioners to use the methodological framework in their projects and encourage academic researchers to evaluate the benefits as well as the shortcomings of its explicit usage.

A more in-depth examination of the options in the methodological framework reveals three gaps in literature that provide interesting directions for future research. Firstly, we observe that redesign catalysts, which provide inspiration for generating process alternatives (e.g. benchmarking process insights, medical guidelines, and technology developments), have received limited attention in the context of method development. A more intensive usage of these external information sources might enable a more complete exploration of attractive process alternatives in healthcare. At the same time, a cookie-cutter approach regarding the use of benchmark and other examples should be prevented (Lee and Pentland 2000). Hence, an open and interesting research challenge is to investigate ways to smartly integrate redesign catalysts in methods for rethinking care processes.

Secondly, an in-depth examination of the framework reveals that existing methods seem to have a strong internal / intra-company focus. This focus is reflected in a limited involvement of patients / customers, suppliers, and external peers in generating process improvement ideas and the lack of an explicit rethinking of the service concept, i.e. the positioning of the process in the complete value network (Patrício et al. 2011). This narrow internal / intra-company focus implies a high risk of missing interesting opportunities for repositioning a care process in relation to patients, general practitioners, and other stakeholders. For example, self-service concepts, outsourcing options, and co-creation possibilities are likely to be easily overlooked. Therefore, we encourage researchers to develop methods that are more geared towards an external / inter-company focus.

Third and finally, we observe that researchers sometimes have investigated similar method options in a rather fragmented way. A case in particular concerns rule-based techniques. Rule-based techniques make use of generic process redesign rules that have been accumulated in literature or practice in order to develop process alternatives (Chai et al. 2005; Nissen 2000; Reijers and Limam Mansar 2005). When studying these rules, information systems researchers have typically limited their attention to the "BPR best practices" literature, whereas researchers in the management sciences domain have focused on "TRIZ innovation principles". More generally, we invite researchers to explore synergy / integration possibilities between existing research efforts with respect to similar method options.

Limitations

Our search has been limited to scientific reports. The authors of most of these reports have focused on *developing* application *domain-independent* methods based on scientific literature, rather than on studying large scale *applications* of methods in *healthcare practice*. This is reflected in the limited amount of healthcare-specific method options (e.g. medical guidelines) in the methodological framework. Hence, a further examination of methods that have been used in process redesign initiatives in healthcare practice is desirable to enrich our findings. This research challenge is at the center of attention in Chapter 3.

2.6 Summary

This systematic literature review presents a methodological framework for generating process improvement ideas in healthcare. This framework contains an overview of method options for six key methodological decision areas: aim, actors, input, output, technique, and tool. Screening this framework enables healthcare practitioners to compose a well-considered method based on the method options as identified by our review. The methodological framework is complemented with recommendations that indicate several improvement directions for methods.

In addition to the methodological framework and its critical evaluation, this review includes an analysis of the research procedures of the studies that were selected to develop the framework. Based on this analysis, we advice academic researchers with regard to building and evaluating new methods.

We contend that, by employing a systematic review methodology, a) a comprehensive methodological framework is developed that represents the scientific body of knowledge in the information systems, management sciences, and health sciences domain, and b) traceable and concrete recommendations are formulated that assist in developing well-designed methods for rethinking care processes.

The next chapter continues with enriching the methodological framework with empirical insights from applications of methods in the healthcare domain. This investigation also aims to extend the list of improvement directions for methods.

3

An enrichment of the methodological framework with empirical insights

Chapter 3

An enrichment of the methodological framework with empirical insights

To provide methodological support for rethinking care processes, a methodological framework has been outlined in the previous chapter. The framework has been based on a systematic literature review that mainly targeted method development studies, i.e. scientific studies introducing a new method for rethinking processes. In this chapter, we enrich the methodological framework with empirical insights by examining applications of methods in healthcare. Towards this end, a cross-case analysis and a field study among consultancy companies were conducted. Using these two research methods, we were able to investigate the completeness of the methodological framework and identify potential enhancements. The results of both research methods show that the original framework covers the lion's share of method options that are selected in healthcare practice. Nonetheless, several areas for further extension and elaboration can be identified.

3.1 Introduction

The framework developed in the previous chapter prevents that practitioners have to rely exclusively on their own experience and intuition to compose a method for rethinking care processes. The framework contains an overview of 60 method options for six key methodological decision areas, i.e. aim, actors, input, output, technique, and tool. It includes knowledge extracted from numerous scientific studies in the information systems, management sciences, and health sciences domain. Notwithstanding the framework's comprehensive coverage, a limitation is that the studies used to create the framework mainly focus on *developing* new methods for generating process improvement ideas. These methods developed in the scientific domain might be different from the methods that are being applied in practice. Hence, it is desirable to enrich the framework with empirical insights from *applications* of methods *in healthcare*. By comparing the selected method options in these practical applications with the ones in the framework, the completeness of the methodological framework can be evaluated and possibilities for further extension and elaboration of methods can be identified.

In this chapter, we discuss two complementary research methods that were used to enrich the methodological framework: a *cross-case analysis* targeting existing case studies in healthcare that discuss an application of a business process redesign method and a *field study* targeting consultancy companies active in rethinking care processes. By analyzing existing case studies, a cross-case analysis makes use of an abundant source of rich field-based information while conserving many resources that would have been needed to conduct multiple, original case studies (Larsson 1993; Lewis 1998). Nonetheless, existing case studies often provide incomplete information (Lewis 1998) and the time-lag between application and publication may prevent gaining insights regarding recent methods for rethinking care processes. Therefore, we complemented the cross-case analysis with a field study by which data is collected via face-to-face interviews (e.g. Cooper and Schindler 2003; Dillman 2000). In this particular case, face-to-face interviews were conducted with senior consultants of consultancy companies. Due to their nature of existence and economies of scale, we expect consultancy companies to be well-experienced and knowledgeable in applying methods for rethinking care processes. Consequently, interviewing senior consultants within these companies offered additional opportunities for evaluating the completeness of the methodological framework and for identifying possibilities for further enhancement of methods.

This chapter is structured as follows. Section 3.2 describes the research methodology outlining the procedures that were followed to execute the cross-case analysis and field study. In Section 3.3, we present the results of both applied research methods. In Section 3.4, we discuss the main findings and limitations of our work. Section 3.5 summarizes this chapter.

3.2 Research methodology

In this section, the procedures with regard to the cross-case analysis (CCA) and the field study among consultancy firms (FSCF) are briefly explained. Extended discussions of the systematic research protocols are available as online reports[1].

3.2.1 Procedure cross-case analysis

By comparing selected method options in case studies with the ones in the methodological framework, the cross-case analysis aims to evaluate the completeness of the framework and to identify possibilities for further enhancing methods.

The scope of this cross-case analysis is constrained to initiatives that aim at redesigning an interdepartmental or inter-organizational care process in a hospital environment. A hospital environment is considered to be a highly suitable development ground for methodological innovations regarding process redesign. In comparison to other sectors in health care, such as mental health care, care for disabled persons and home care, processes in hospitals typically have a shorter throughput time and higher volume and are generally perceived to be more complex (Vissers and Beech 2005).

To establish the representativeness of the findings for a hospital context, the cross-case analysis contains a systematic search and selection procedure as well as a robust data extraction and coding procedure. Three senior researchers reviewed these procedures. Together, the three senior researchers covered three research domains that are relevant in the context of rethinking care processes: health sciences, management sciences, and information systems. Below, the search and selection procedure as well as the data extraction and coding procedure are summarized.

[1] Protocol cross-case analysis: https://robvanwersch.files.wordpress.com/2016/01/cca-protocol-ch-3.pdf;
Protocol field study among consultancy firms: https://robvanwersch.files.wordpress.com/2016/01/fscf-protocol-ch-3.pdf

Search and selection

In order to identify case studies discussing applications of methods for rethinking care processes, the electronic databases Medline, ABI/Inform, and INSPEC were used to provide coverage of the three relevant research domains. In order to create an extensive Boolean search expression for each electronic database, synonyms, acronyms, and abbreviations related to the terms “process”, “redesign”, and “hospital” were systematically investigated (see Appendix B.1). This Boolean expression was complemented with database-specific headings. Besides querying electronic databases, we manually screened the International Journal of Care Pathways, which was outside the scope of the search engines. To identify high quality studies efficiently, we targeted only peer-reviewed journal articles and conference papers in line with recommendations of Rowley and Slack (2004) and Webster and Watson (2002). In addition, only articles in English, containing an abstract, and published after 2005 were considered.

Similar to the systematic literature review discussed in Chapter 2, two reviewers independently performed a two-stage relevance screening and a quality screening to select relevant and high quality studies. All relevance and quality screening activities were based on detailed inclusion and exclusion criteria (see Appendix B.2). As part of the relevance screening, we checked, for example, whether the described redesign initiative focuses on *generating process improvement ideas*. As a consequence of this relevance criterion, several case studies that only aimed at modelling or analyzing the as-is process or implementing a pre-defined process improvement idea were excluded. As part of the quality screening, we checked, among other things, whether the case study provides a clear description of the method applied for rethinking care processes. Inter-rater-agreement with regard to all screening activities was assessed by means of the Kappa statistic (Fink 2010) and any disagreements were resolved by consensus.

Data extraction and coding

We decided to extract two types of data elements from the included case studies based on a detailed data extraction form (see Appendix B.3): *method elements* and *case study characteristics*.

To enrich the methodological framework, data was extracted regarding the six *method elements* discussed in Chapter 2: (1) *aim*, (2) *actors*, (3) *input*, (4) *output*, (5) *technique*, and (6) *tool*.

In addition, several *case study characteristics* were extracted to obtain insights into the kind of process redesign initiatives covered by the case studies: (1) the *label* used by the authors to refer to business process redesign, (2) the *country* where the initiative took place, (3) the *setting* in which the initiative took place (e.g. hospital or inter-organizational: GP - hospital - revalidation clinic), (4) the *patient group* that was targeted by the initiative (classified according to ICD-10 Chapters (World Health Organization, 2013), and (5) the *annual patient volume* of the patient group that was the subject of investigation.

Analogously to the systematic literature review in Chapter 2, we extracted and coded all data fragments in an iterative fashion by making use of a structured procedure. One reviewer extracted data from all case studies and assigned an initial code to each data fragment, using terms from the methodological framework whenever appropriate. Another reviewer independently extracted and coded data for a 10% random sample of the reports. Subsequently, discrepancies were solved by consensus. As proposed by Brereton et al. (2007), we used an extractor-checker construction to extract and code data from the remaining studies efficiently. Finally, the relationships between the initial codings were analyzed in more detail by both reviewers. This axial coding step (Wolfswinkel et al. 2013) resulted in updated concepts and categories.

Regarding the *patient group*, i.e. the fourth case study characteristic, a different coding procedure was followed. After extracting the relevant data fragments, two medical coding specialists of Maastricht University Medical Center independently classified the extracted data fragments according to the Chapters of the International Classification of Diseases (ICD 10) (World Health Organization, 2013). Coding discrepancies were again solved by consensus.

3.2.2 Procedure field study

Analogously to the cross-case analysis, the aim of the field study among consultancy firms is to investigate the completeness of the methodological framework and to identify opportunities for enhancing methods.

The field study consisted of interviews with senior consultants working for Dutch consultancy firms that have been active in rethinking care processes. These interviews aimed at systematically comparing the method options that are typically selected by consultants to rethink care processes with the ones in the methodological framework. Within each company, two interviewers conducted a 1.5 hours interview session with two senior consultants using a semi-structured interview protocol. One of the consultants had to be active in the healthcare domain and one had to be involved in process redesign projects outside the healthcare domain. It is assumed that this diversity in domain expertise fosters open-minded and concrete ideas regarding opportunities for further elaboration and extension of methods. The detailed field study protocol is summarized below. We discuss the procedure that was used to search and select consultancy companies, the interview set-up, as well as the data extraction and coding procedure.

Search and selection

In line with recommendations from several researchers (Benbasat et al. 1987; Eisenhardt 1989; Stuart et al. 2002), the selection of consultancy firms was based on their potential to contribute to the research objective rather than concerns for randomness.

We performed a three-stage screening based on an electronic database (Company.info) to identify relevant Dutch consultancy firms. This database contained detailed information about more than 2 million organizations active in the Netherlands. The screening contained (1) a selection of relevant company categories (e.g. management consultancy and technical design and consultancy for process engineering), (2) a screening of the company descriptions in this database (e.g. checking whether the company was not specialized in another domain than process management, such as construction engineering), and (3) a website screening of the companies that passed stage 2 (e.g. checking whether the company was active in redesigning business processes in the healthcare domain and at least one other application domain). After this three-stage screening, we screened all 2011 magazines of a popular Dutch Business Process Management (BPM) periodical and its related website to further establish that potentially relevant consultancy firms did not remain unidentified. All screening activities were performed by two reviewers based on detailed inclusion and exclusion criteria (see Appendix B.4). After the identification of the set of potentially relevant consultancy firms, the identified firms were contacted to fill in a brief survey in order to verify whether the companies fulfilled all participation criteria (i.e. recently active in rethinking inter-departmental processes in the healthcare domain and at least one other application domain). The companies fulfilling all criteria were invited to participate in an interview session.

Interview set-up

During the tape-recorded, semi-structured interview session with each company, the six method elements mentioned earlier were addressed successively. Each method element was discussed in three rounds:

1. *Open question:* After a brief explanation of the method element, the interview participants were asked to come up with method options that are part of their methods for rethinking processes (e.g. what techniques does your company use to generate process improvement ideas?).
2. *Presentation of methodological framework:* After closure of the open question, we showed the part of the methodological framework that was related to the method element under study. As recommended by Hove and Anda (2005), a visual representation of the methodological framework was shown followed by an oral explanation. Subsequently, the interview participants were asked to identify missing method options.
3. *Generalizability question:* Finally, we asked interview participants to indicate differences between the selection of method options in the healthcare domain and other application domains.

Data extraction and coding

Based on transcriptions of the recorded audio tapes, data was extracted and coded regarding the method elements in line with the procedures of the cross-case analysis. Within one week after the interview, interview participants received the extraction and coding results to enable them to validate our interpretations.

3.3 Results

This section presents the results of the cross-case analysis and the field study among consultancy firms.

3.3.1 Results cross-case analysis

Below, we start with explaining the search and selection results of the cross-case analysis. Subsequently, we present the data extraction and coding results with regard to *case study characteristics* and *method elements*.

Search and selection results

The search and selection results with regard to the cross-case analysis are graphically summarized in Figure 3.1.

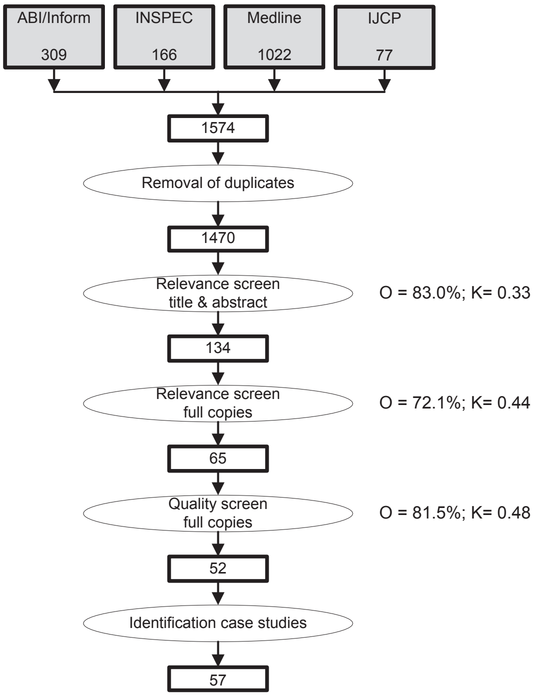


Figure 3.1. Flowchart search and selection results cross-case analysis.
O= Observed agreement; K = Kappa statistic.

The electronic and manual search retrieved 1470 non-duplicate articles. 52 out of these 1470 studies passed the two-stage relevance screening and quality screening. For all relevance and quality screening activities, inter-rater-agreement, as determined by Kappa statistics, is acceptable (min Kappa = 0.33; max Kappa = 0.48). Note that all studies were reviewed by two reviewers and that all disagreements were resolved by consensus. Several identified studies reported about multiple case studies. In total, 57 case studies were selected for further examination.

Data extraction and coding results

Case study characteristics

The set of studies consists of 51 journal papers (98%) and one conference paper (2%). The characteristics of the case studies that are part of these papers are summarized in Table 3.1.

Case study characteristic		*No. of case studies*	*Perc. of case studies*
Label	Clinical pathways	20	35%
	Lean	16	28%
	Integrated care pathways	5	9%
	Lean Six Sigma	2	4%
	Six Sigma	2	4%
	Business Process Redesign	2	4%
	Kaizen	1	2%
	No label	9	16%
Country	USA	26	46%
	UK	7	12%
	The Netherlands	4	7%
	Canada	4	7%
	Australia	3	5%
	Taiwan	2	4%
	Germany	2	4%
	China	2	4%
	Spain	2	4%
	Belgium	1	2%
	Switzerland	1	2%
	Japan	1	2%
	Sweden	1	2%
	Singapore	1	2%
Setting	Hospital	51	89%
	Inter-organizational (including hospital)	6	11%
Patient group (based on ICD-10 Chapters)	Neoplasms	9	16%
	Diseases of the circulatory system	7	12%
	Diseases of the respiratory system	4	7%
	Diseases of the digestive system	2	4%
	Diseases of the genitourinary system	2	4%
	Injury, poisoning and certain other consequences of external causes	2	4%
	Diseases of the eye and adnexa	1	2%
	Factors influencing health status and contact with health services	1	2%
	Diseases of the musculoskeletal system and connective tissue	1	2%
	Diseases of the nervous system	1	2%
	Multiple classifications possible	6	11%
	No classification possible	21	37%
Annual patient volume	1-100 patient visits per year	15	26%
	101-1.000 patient visits per year	13	23%
	1.001-10.000 patient visits per year	6	11%
	>10.000 patient visits per year	15	26%
	Not specified	8	14%

Table 3.1. Case study characteristics of cross-case analysis.

Table 3.1 shows that seven different *labels* were used by the authors of the case studies to refer to the redesign of business processes. The most popular labels assigned are Clinical pathways (35%) and Lean (28%). The process redesign initiatives took place in 14 different *countries*. A large majority of the projects were performed in countries in North America (53%) and Western-Europe (32%). With regard to the *setting,* most of the initiatives investigated processes that do not transcend the organizational borders of a single hospital (89%). Only a few initiatives targeted cross-organizational processes (11%), e.g. including sub-processes at the general practitioner or rehabilitation clinic. Regarding the *patient groups* that were targeted by the process redesign initiatives, 10 out of 22 ICD-10 chapters are covered by the case studies. The patient groups that were most often investigated are

Neoplasms (16%) and Diseases of the circulatory system (12%). Finally, Table 3.1 shows that the *annual patient volumes* of the patient groups that were the subject of investigation cover a wide range of volumes. The categories “1-100 patient visits per year” and “>10.000 patient visits per year” are both represented by approximately a quarter of the studies (26%).

A detailed overview of all case study characteristics per study is available as an online report[2].

Method elements

As explained in the research methodology section, we decided to extract and code data fragments regarding six methodological decision areas. The *aim* (n=57; 100%) and *input* (n=57; 100%) element are addressed in all case studies. The *output* (n=55; 96%) and *actors* (n=50; 88%) element are discussed in a large majority of the case studies. On the contrary, the *technique* (n=5; 9%) and *tool* (n=2; 4%) element have received considerably less attention. More detailed results regarding the case study codings are shown in Table 3.2. More precisely, we indicate for each method option of the original methodological framework, the number of case studies that selected this option as part of their method for rethinking care processes. In case a method option in a case study was not covered by the existing methodological framework, the method option was added to the framework and highlighted in **bold*** in Table 3.2. A detailed overview of all method element related codings per study is available as an online report[3].

Method element	*Category*	*Sub-category*	*Method option*	*No. of CS*
Aim	Performance Dimensions		Revenue	15
			Costs	21
			Time	44
		Quality	Unspecified	0
			External quality	47
			Internal quality	6
			Flexibility	0
	Degree of improvement		Radical improvement	0
			Incremental improvement	1
Actors	Daily involved		Process actor	23
			Management	15
	Advising	Supporting staff	BPR specialist	13
			Finance specialist	1
			HR specialist	1
			IS specialist	3
			Marketing specialist	1
			Quality assurance specialist*	5
			Customer / patient	1
			Supplier	2
			External consultant	10
			Health insurance commissioner*	1
			Peer	1

Table 3.2. Method options (aim and actors) addressed by CS. CS = Case studies. * option identified in cross-case analysis that was not part of the original methodological framework.

[2] https://robvanwersch.files.wordpress.com/2016/01/study-characteristic-codings-per-study-cca-ch-3.xlsx
[3] https://robvanwersch.files.wordpress.com/2016/01/method-element-codings-per-study-cca-ch-3.xlsx

Method element	Category	Sub-category	Method option	No. of CS
Input	Redesign requirements		Process output goals	13
			Stakeholder / patient needs	4
	Redesign limitations		Constraints	0
			Risks	0
	AS-IS process specification		Textual process description	2
			Process model	26
			Simulation model	2
			Physical lay-out*	3
	Process weaknesses		Process output measures	52
			Process measures	6
			Different opinions regarding AS-IS process specification	0
			Problem investigation	22
			Culture scan	0
	Redesign catalysts		Medical guidelines / key interventions	19
			Previous solutions	7
			Benchmark process insights	11
			Benchmark process models	0
			Technology developments	0
			Industry value-net	0
Output	TO-BE specifications		TO-BE service concepts	0
		TO-BE process specifications	Summary redesign proposals	37
			Textual process descriptions	16
			Process models	11
			Simulation models	2
			Physical lay-outs*	2
			Check-lists*	14
			TO-BE exception handlers	0
	TO-BE assessments		Impact analyses	4
			Force-field-analyses	2
Technique	Unstructured		Brainstorming	3
			Out-of-the-Box thinking	0
			Visioning	0
			Unspecified	1
	Semi-structured		Delphi	0
			Nominal group	1
			Multi-level design	0
			Grammar-based	0
	Structured		Rule-based	0
			Case-based	0
			Repository-based	0
Tool			Communication	2
			Voting	0
			Modeling	0
			Simulation	0
			Repository	0
			Specific	0

Table 3.2 (continued). Method options (input, output, technique, and tool) addressed by CS. CS = Case studies. * option identified in cross-case analysis that was not part of the original methodological framework.

An analysis of Table 3.2 shows that 62% of all method options in the original methodological framework are covered by at least one case study. A more detailed examination of the different method elements reveals that all options with regard to the *actors* element are covered by at least one case study (11 out of 11 options; 100%). Also, the options of the *aim* (6 out of 8 options; 75%), *output* (6 out of 8 options; 75%) and *input* (11 out of 18 options; 68%) element are well covered. By contrast, the options of the *technique* (2 out of 10 options; 20%) and *tool* (1 out of 5 options; 20%) element are considerably less covered.

In addition, Table 3.2 shows that five method options are added to the methodological framework that originally contained 60 method options. More specifically, the *actors* element is extended with the *quality assurance specialist* (n=5) and the *health insurance commissioner* (n=1)*,* the *input* element includes the *physical lay-out* (n=2) as an additional option, and the *output* element is extended with *physical lay-outs* (n=2) and *check-lists* (n=14).

3.3.2 Results field study

Below, we start with discussing the results regarding the search and selection of the consultancy companies participating in the field study. Subsequently, we outline the data extraction and coding results regarding the method elements that were based on the interview transcriptions.

Search and selection results

After the selection of the company categories in the Company.info database, we screened 86 companies in order to select relevant companies for the field study. 12 out of these 86 companies passed the related screenings. In addition, five out of seven companies identified by investigating a Dutch BPM periodical were selected for further investigation. In total, 17 (12 + 5) companies received a brief survey in order to assess whether these companies fulfilled our participation criteria. Nine out of these 17 companies (53%) returned a completed survey. Eight out of these nine organizations (89%) fulfilled the criteria and were invited to participate in the interview part of our field study. Six out of these eight companies (75%) accepted our invitation, participated, and validated the interview summaries.

Data extraction and coding results

The data extraction and coding results regarding round 1 (open question) and 2 (presentation of the methodological framework) of the interview sessions are summarized in Table 3.3. Note that round 3 (generalizability question) did not reveal differences between the healthcare domain and other application domains regarding the method options that are typically considered, except several subtle differences in preferences (e.g. process models are less often created in healthcare than in the banking and insurance industry). In Table 3.3, we indicate for each method option the number of companies that discussed this option during the interview session. In case a method option discussed was not covered by the existing methodological framework, the method option was added to the framework and highlighted in **bold****(*) in Table 3.3. A detailed overview of all interview results is available as an online report[4].

Method element	*Category*	*Sub-category*	*Method option*	*No. of CF (r1)*	*No. of CF (r2)*	*No. of CF (r1+2)*
Aim	Performance Dimensions		Revenue	2	0	2
			Costs	6	0	6
			Time	4	0	4
		Quality	Unspecified	0	0	0
			External quality	6	0	6
			Internal quality	0	0	0
			Flexibility	2	0	2
			Compliance to legal rules**	4	1	5
	Degree of Improvement		Radical improvement	0	0	0
			Incremental improvement	0	0	0

Table 3.3. Method options (aim) addressed by CF. CF = Consultancy firms; r1 = round 1 of interview sessions (open question); r2 = round 2 of interview sessions (presentation methodological framework); * option only identified in cross-case analysis; ** option only identified in field study; *** option identified in cross-case analysis and field study.

[4] https://robvanwersch.files.wordpress.com/2016/01/interview-codings-per-company-fscf-ch-3.xlsx

Method element	*Category*	*Sub-category*	*Method option*	*No. of CF (r1)*	*No. of CF (r2)*	*No. of CF (r1+2)*
Actors	Daily involved		Process actor	6	0	6
			Management	5	0	5
	Advising	Supporting staff	BPR specialist	0	0	0
			Finance specialist	3	0	3
			HR specialist	2	0	2
			IS specialist	3	0	3
			Marketing specialist	0	0	0
			Quality assurance specialist***	3	3	6
			Customer / patient	3	0	3
			Supplier	1	0	1
			External consultant	6	0	6
			Employer representative**	1	0	1
			Health insurance commissioner***	1	0	1
			Peer	3	0	3
Input	Redesign requirements		Process output goals	4	0	4
			Stakeholder / patient needs	1	0	1
			Legislation**	0	3	3
	Redesign limitations		Constraints	4	0	4
			Risks	0	0	0
	AS-IS process specification		Textual process description	1	0	1
			Process model	6	0	6
			Simulation model	0	0	0
			Physical lay-out*	0	0	0
	Process weaknesses		Process output measures	6	0	6
			Process measures	0	0	0
			Different opinions regarding AS-IS process specification	0	0	0
			Problem investigation	6	0	6
			Culture scan	0	0	0
	Redesign catalysts		Medical guidelines / key interventions	0	0	0
			Previous solutions	1	0	1
			Benchmark process insights	3	0	3
			Benchmark process models	0	0	0
			Technology developments	0	0	0
			Industry value-net	0	0	0
Output	TO-BE specifications		TO-BE service concepts	0	0	0
		TO-BE process specifications	Summary redesign proposals	5	0	5
			Textual process descriptions	1	0	1
			Process models	5	0	5
			Simulation models	0	0	0
			Physical lay-outs*	0	0	0
			Check-lists*	0	0	0
			TO-BE exception handlers	1	0	1
	TO-BE assessments		Impact analyses	5	0	5
			Force-field-analyses	0	0	0
Technique	Unstructured		Brainstorming	6	0	6
			Out-of-the-Box thinking	1	0	1
			Visioning	0	0	0
			Unspecified	0	0	0
	Semi-structured		Delphi	0	0	0
			Nominal group	0	0	0
			Multi-level design	0	0	0
			Grammar-based	0	0	0
	Structured		Rule-based	0	0	0
			Case-based	0	0	0
			Repository-based	0	0	0
Tool			Communication	0	0	6
			Voting	0	0	0
			Modeling	6	0	0
			Simulation	0	0	0
			Repository	0	0	0
			Specific	0	0	0

Table 3.3 (continued). Method options (actors, input, output, technique, and tool) addressed by CF. CF = Consultancy Firms; r1 = round 1 of interview sessions (open question); r2 = round 2 of interview sessions (presentation methodological framework); * option only identified in cross-case analysis; ** option only identified in field study; *** option identified in cross-case analysis and field study.

An examination of Table 3.3 reveals that 52% of all method options in the original methodological framework were discussed during the *open question* interview round by a consultant of at least one of the participating consultancy firms. Taking also into account the coverage of the cross-case analysis (62%), 67% of all method options in the framework are covered by the cross-case analysis and/or field study among consultancy firms.

A detailed analysis of Table 3.3 shows that the degree of coverage of the different method elements in the field study is well-aligned with the results of the cross-case analysis. A large majority of the options with regard to the *actors* (9 out of 11 option; 83%), *aim* (5 out of 8 options; 63%) and *output* (5 out of 8 option; 63%) element are covered by at least one consultancy firm during the *open question* round. Also in agreement with the cross-case analysis results, the input element follows suit (9 out of 18 options; 50%). Similarly, the *technique* (2 out of 10 options; 20%) and *tool* (1 out of 5 options; 20%) options are considerably less covered.

Table 3.3 also shows that two out of five method option extensions, identified as part of the cross-case analysis, were addressed in the field study. More precisely, the *quality assurance specialist* (n=6) and the *health insurance commissioner* (n=1) were identified as missing options by at least one consultancy firm during the interview sessions. Furthermore, the results of the interview sessions reveal that the methodological framework can be further extended with three new options. The *aim* element includes *compliance to legal rules* (n=5) as an additional option. Related to this, the *input* element is extended with *legislation* (n=3). The third and final extension is related to the *actors* element. It includes the *employer representative* as an additional option (n=1).

In Table 3.4, we provide definitions for all new method options identified as part of the cross-case analysis and the field study. The complete methodological framework including definitions can be found in Appendix B.5.

Method option	*Method element*	*(Sub-)category*	*Definition method option*
Compliance to legal rules	Aim	Performance dimension	Adherence to laws, regulations, and other requirements set by government or related regulatory institutes.
Quality assurance specialist	Actor	Advising supporting staff	Supporting staff specialist who has specific expertise in ensuring that legal and other quality-related requirements are met by the services provided by an organization.
Health insurance commissioner	Actor	Advising actor	Representative of a healthcare insurance company.
Employer representative	Actor	Advising actor	Representative of an employer's organisation.
Legislation	Input	Redesign requirements	Laws, regulations, and other requirements set by government or related regulatory institutes.
Physical lay-out	Input & Output	AS-IS / TO-BE process specifications	Physical arrangement of a process.
Check-lists	Output	TO-BE process specifications	Organized instruments that outline criteria of consideration for TO-BE processes. It functions as a support resource by delineating and categorizing items as a list -a format that simplifies conceptualization and recall of information (Hales et al. 2008).

Table 3.4. Definitions of method options identified by cross-case analysis and/or field study.

3.4 Discussion

An examination of the findings of the cross-case analysis and the field study among consultancy firms reveals that the original methodological framework covers the lion's share of method options that are selected in process redesign projects in healthcare practice. As one consultant noted: “The framework includes more options than I could think of myself. Nonetheless, I recognize all options as feasible ones".

Notwithstanding the comprehensive coverage of the original framework, several areas for further elaboration and extension can be identified. Firstly, we discuss some key findings with regard to groups of method options that seem to be largely neglected during business process redesign initiatives in healthcare. Secondly, we discuss potential enhancements based on the method options that were newly identified during the cross-case analysis and/or field study. We end this section with the limitations of our work.

Existing method options that are worth further elaboration

In line with the findings of the systematic literature review in Chapter 2, the results of the cross-case analysis and field study reveal that many *redesign catalysts* (e.g. benchmarking process models and technology developments) have received limited attention in the context of rethinking care processes in practice. As argued before in Chapter 2, a more intensive usage of redesign catalysts as part of redesign initiatives might enable a more complete exploration of attractive process alternatives. On that account, the results of the cross-case analysis and field study confirm that the smart integration of redesign catalysts in methods for rethinking care processes is still worth further investigation.

In accordance with the findings of the systematic literature review, we also observe that applied methods for rethinking care processes have a strong internal / intra-company focus. A limited involvement of *patients*, *suppliers*, *healthcare insurance commissioners*, and *external peers* in generating process improvement ideas, as well as the absence of an explicit rethinking of the *service concept* are illustrative for this finding. This implies that also initiatives in practice are vulnerable to miss attractive redesign possibilities, such as self-service, outsourcing and co-creation opportunities. As such, this finding provides additional support for our related recommendation in Chapter 2, i.e. to elaborate on opportunities for gearing methods more towards an external / inter-company focus.

In addition to providing additional support for the recommendations of the systematic literature review, the results of the cross-case analysis and field study led to the identification of two new areas that are worth to further elaborate upon. More specifically, the results of both research methods indicate that a large majority of available method options regarding *techniques* and *tools* have been largely neglected during business process redesign initiatives in healthcare.

With regard to available *techniques* for rethinking care processes, it can be observed that the uptake of semi-structured and structured techniques (see Chapter 2) has been severely limited. One cause might be that, except experimental evidence for nominal group and Delphi techniques (Van de Ven and Delbecq 1974), the evidence in favour of these techniques is limited and is largely anecdotal in nature. During the interview sessions it became apparent that, in particular, the performance of rule-based techniques is worth a more rigorous examination. These techniques make use of generic process redesign rules that have accumulated in literature and practice to develop process alternatives (Chai et al. 2005; Nissen 2000; Reijers and Limam Mansar 2005). One of the consultants stressed the potential of these techniques as follows: "Surprisingly, we do not document our own solutions concepts, making a re-application of generic solution concepts difficult. The use of a rule-based technique seems to be very valuable. Currently, the results of a redesign session are highly dependent on the consultant who chairs the session." A consultant representing another company asked for future research with regard to the potential of these techniques: "If you perform a structured analysis and are able to identify a list of concrete root-causes, then solutions are often rather trivial. Having performed such a structured analysis, it is questionable whether the use of structured techniques for generating solutions has a lot of added value". Based on these discussions, it is recommended to evaluate and compare the performance of different techniques by means of lab or field experiments.

Similar to the uptake of advanced techniques, the uptake of many *tool* functionalities has been limited. Concrete reasons were identified by consultants of two companies. One consultant noted: “Many advantages of advanced tools, such as groupware systems, can be covered by using appropriate workshop procedures. For example, post-its can be used to ensure that everybody contributes to the discussion. Post-its can also be used to replace advanced voting systems." A consultant of another firm replied highly similar: “We cover the advantages of tool functionalities (except simulation) by using suitable paper-based procedures. We consider simulation to be highly time-consuming and expensive in most of our projects". Given these remarks, tool developers are recommended to carefully reflect on user requirements and to communicate distinctive features more clearly.

New method options

As part of the cross-case analysis and/or the field study, we also identified several method options that are not covered by the original methodological framework. In particular, the following three areas are worth to investigate further: *compliance management*, *physical lay-out*, and *check-lists*.

As part of this research endeavour, three *compliance management* related extensions of the methodological framework are suggested: *compliance to legal rules* (*aim* option), the *quality assurance specialist* (*actors* option), and *legislation* (*input* option). These results imply that, whereas practitioners are aware of the importance of ensuring *compliant* business processes, existing scientific methods for rethinking care processes lack related safeguards. As a consequence, applications of existing methods are vulnerable to violate laws, regulations, or any other requirements set by government or related regulatory institutes. This finding is in line with the frequently-cited work of Sadiq et al. (2007) who argue for a systematic approach in order to achieve convergence between business objectives and control objectives during business process redesign. They offer process model and legislation related representation techniques that are instrumental in the redesign of compliant business processes. Consequently, we advice academic researchers to take notice of how compliance issues can be covered efficiently and effectively when developing methods for rethinking care processes.

Moreover, the *physical lay-out* of healthcare organizations is an underestimated aspect in existing scientific methods for rethinking care processes. Whereas the interplay between the physical arrangement of equipment and process design has gained widespread attention in manufacturing engineering (Hopp and Spearman 2008), existing methods for rethinking care processes do not include the physical lay-out as an important input or output element. A potential cause might be that many developed methods for rethinking processes are biased towards an application in the administrative domain where the physical lay-out has a less dominant influence on process performance (Reijers and Limam Mansar 2005). As part of the customization of methods for the healthcare domain, researchers are recommended to investigate how the interplay between the design of the physical lay-out and the process can be adequately addressed.

Finally, we propose that the creation of *check-lists* as part of methods for rethinking care processes is worth further elaboration. The cross-case analysis results suggest that several redesign teams prefer check-lists over process models as output of redesign sessions. Hales et al. (2008) defined check-lists as "an organized instrument that outlines criteria of consideration for a particular process. It functions as a support resource by delineating and categorizing items as a list - a format that simplifies conceptualization and recall of information". Due to these characteristics, check-lists are highly suitable artifacts for daily practical purposes. Nonetheless, check-lists offer limited possibilities for graphically outlining the complex relationships between activities in processes. Such representations offered by process models might be useful for future redesign purposes. As such, check-lists and process models are likely to offer complementary benefits. However, the independent creation of these is time-consuming. Hence, we consider the development of tool support for the efficient creation of mutually consistent check-lists and process models an interesting avenue for future research.

Limitations

Our cross-case analysis included only *hospital* case studies published in *scientific* journal or conference papers. These biases make generalizing our findings to healthcare projects with an exclusively practical objective difficult. Nonetheless, the analysis of case study characteristics shows that projects with a wide range of labels, countries, patient groups, and related volumes are covered. Also, we complemented the cross-case analysis with a field study among consultancy firms to prevent severe biases. However, special caution is still needed to generalize our findings to initiatives that target cross-organizational processes or processes in a non-hospital environment.

3.5 Summary

In order to provide methodological support for rethinking care processes, we have introduced a methodological framework based on a systematic literature review in the previous chapter. In the current chapter, the methodological framework is enriched with empirical insights of method applications in healthcare. A cross-case analysis and a field study among consultancy firms were conducted towards this end.

The results of these research methods show that the original framework covers the large majority of method options that are selected in healthcare practice. Nonetheless, we were able to gain additional insights with regard to opportunities for extending and elaborating methods for rethinking care processes. As such, we were able to extend the list of improvement directions for methods as discussed in the previous chapter. We contend that, by employing two systematic and complementary research methods, traceable and concrete recommendations are formulated to further advance methodological support for generating process improvement ideas for care processes.

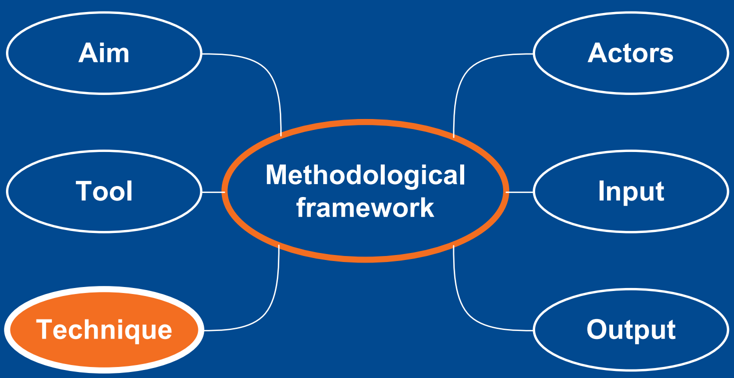
Among other things, there is room to develop and evaluate a more advanced *technique* for rethinking care processes. Given its expected improvement potential and the available expertise in our research group, this challenge will be at the center of attention in the second part of this thesis.

Part 2

The Rethinking of Processes (RePro) technique

"Don't reinvent the wheel, just realign it." (Anthony J. D'Angelo)

"All life is an experiment. The more experiments you make the better." (Ralph Waldo Emerson)



4

The development of the RePro technique*

* **This chapter is based on:**
Vanwersch R.J.B., Pufahl, L., Vanderfeesten, I., & Reijers, H.A. (2014). *The RePro technique: a new, systematic technique for rethinking care processes* (Beta working paper no. 465). Eindhoven, NL: Eindhoven University of Technology.

Chapter 4

The development of the RePro technique

Redesigning care processes is challenging and requires a well thought-out technique that supports healthcare practitioners in generating process improvement ideas. In this chapter, we argue that adequate support is not offered by existing techniques. As a response, we present a new, systematic technique for rethinking care processes: the Rethinking of Processes (RePro) technique. The backbone of this technique is a set of process improvement principles. These principles are based on solutions that have been applied previously and seem worthwhile to replicate in another situation or setting. The RePro technique also includes a procedure that guides practitioners in applying the principles. In this way, the RePro technique offers support for a more complete exploration of the full range of process improvement possibilities.

4.1 Introduction

The analysis of applications of methods in Chapter 3 confirmed that traditional creativity techniques, such as brainstorming, are still the most often applied techniques for rethinking care processes. Such techniques lack a solution for the personal inertia to search for process improvement possibilities that are different from familiar directions (Chai et al. 2005). In other words, a systematic exploration of the full range of process improvement possibilities is not enabled (Chai et al. 2005; Limam Mansar et al. 2009). Consequently, traditional brainstorms are vulnerable to biased choices and may miss many attractive process redesign possibilities. In this way, the full redesign potential in terms of, for example, reducing processes' costs and throughput times, as well as improving patient satisfaction is not achieved.

As outlined in Chapter 2, several alternatives are available for traditional creativity techniques. In particular, three kinds of techniques are available that, in contrast to traditional creativity techniques, offer guidance regarding the kind of process alternatives that are worth consideration: *repository-based*, *case-based*, and *rule-based* techniques. In this chapter, we briefly discuss the strengths and weaknesses of these techniques and present a new technique, i.e. the Rethinking of Processes (RePro) technique, which integrates and extends two existing rule-based techniques. The RePro technique supports healthcare practitioners in a workshop setting to generate process improvement ideas that mainly aim at reducing processes' costs and throughput times as well as improving patient satisfaction. Practitioners can be either external or internal process analysts with an educational background in process management or senior healthcare professionals with a medical background.

This chapter is structured as follows. In Section 4.2, we discuss the strengths and weaknesses of existing *repository-based, case-based*, and *rule-based* techniques. In

Section 4.3, we explain the core building blocks of the RePro technique. Section 4.4 describes the research methodology followed to build the RePro technique. In Section 4.5 and 4.6, we present the intermediate and final outcomes of the development process respectively. Section 4.7 summarizes this chapter.

4.2 Background

In contrast to traditional creativity techniques, *repository-based*, *case-based*, and *rule-based* techniques (see Chapter 2) guide practitioners in a systematic and complete exploration of the full range of redesign possibilities. Consequently, it is expected that effective process alternatives are more likely to be identified as compared to traditional brainstorming.

A *repository-based* technique assumes the existence of a repository that includes specifications of numerous existing processes (e.g. Bernstein et al. 1999; Klein and Petti 2006; Malone et al. 1999; Margherita et al. 2007). As a first step, practitioners are asked to determine the core activities of the process under study. Subsequently, they are able to explore the process variants available in the repository in a systematic way. As a final step, practitioners select the most suitable process design.

A *case-based* technique makes use of a library of well-documented previous business process redesign projects, i.e. BPR cases (e.g. Limam Mansar et al. 2003). This technique enables an efficient identification of relevant earlier BPR cases based on a description of several characteristics of the ongoing BPR case. These earlier BPR cases offer process improvement proposals that can be worthwhile to consider for the process under study.

A *rule-based* technique makes use of generic process redesign rules or principles that have accumulated in literature or practice to develop process alternatives (Chai et al. 2005; Nissen 2000; Reijers and Limam Mansar 2005). The premise of this technique is that specific process problems can be translated to generic process problems, for which generic principles can offer generic process solutions. An example of a generic principle is the parallelism principle, which states that redesign participants should consider executing tasks in parallel. As the technique's final step, the generic process solutions have to be translated to specific process solutions.

When comparing the principles of the *rule-based* technique with concrete variants offered by the *repository-based* technique and concrete process improvement proposals provided by the *case-based* technique, it can be concluded that *rule-based* techniques offer more generic redesign guidance. Although this might be considered a weakness, this higher level of abstraction is likely to enable practitioners to generate more diverse and more original process solutions. In addition, *rule-based* techniques do not require the availability and maintenance of a database with either process descriptions or descriptions of process improvement projects. Based on the reasoning above, *rule-based* techniques form the basis of the new RePro technique that is developed as part of this research endeavour.

4.3 Core building blocks of RePro technique

The RePro technique contains two components: (1) a set of process improvement principles and (2) a procedure that guides practitioners in applying the principles. In the remainder of this section, we discuss the core building blocks for each of these components of the RePro technique.

4.3.1. Building blocks of RePro principles

By means of our systematic literature review, as discussed in Chapter 2, we identified two comprehensive sets of process improvement principles: *BPR best practices* and *TRIZ innovation principles*. These two groups of principles form the building blocks of the set of RePro principles. In the remainder of this section, these two building blocks are discussed in more detail and their relevance for rethinking care processes is further explained.

BPR best practices

The set of *BPR best practices* contains 29 best practices that were derived from a literature review (Reijers and Limam Mansar 2005). The BPR best practices are categorized in a framework and are oriented towards the (see Figure 4.1):

- *External environment*, which address the improvement of the collaboration and communication with third parties;
- *Customers,* which focus on improving contacts with customers;
- *Business process operation*, which consider how to implement the workflow;
- *Business process behavior*, which focus on when the workflow is executed;
- *Organization*, which consider both the structure of the organization (mostly the allocation of resources) and the resources involved (types and number);
- *Information*, which address the information the business process uses or creates;
- *Technology*, which focus on the technology the business process uses.

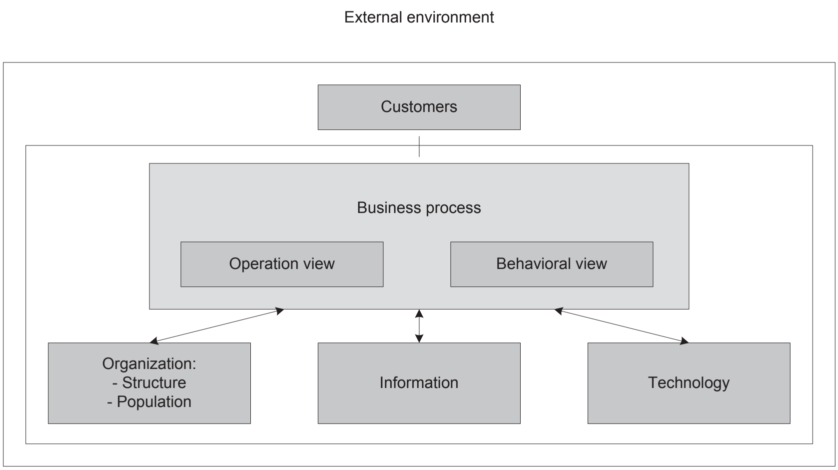


Figure 4.1. Categories used to categorize BPR best practices (Alter 1999; Reijers and Limam Mansar 2005).

The set of BPR best practices has been gathered with a bias towards application in the administrative domain. Due to the fact that many care processes contain multiple administrative sub-processes (e.g. scheduling a consultation appointment, checking an electronic patient record, and writing a discharge letter), it is reasonable to expect that BPR best practices are relevant in the context of care processes. A prior successful application of the set of BPR best practices in healthcare (Jansen-Vullers and Reijers 2005) provides support for this expectation. Nonetheless, the set's bias towards the administrative domain raises concerns about the completeness of the set of BPR best practices for care processes. For example, in contrast to many administrative processes where digital information objects are mainly processed, many care processes require the active involvement of patients throughout the process. Due to this difference, other process alternatives related to the involvement of patients might become of interest, such as changes with regard to the physical lay-out of the process. Consequently, further research is needed to investigate potential enhancements for the existing set of BPR best practices.

TRIZ innovation principles

The set of *TRIZ innovation principles* is a source that potentially offers these enhancements. TRIZ is the Russian acronym for "Theory of Inventive Problem Solving" (Chai et al. 2005). TRIZ was developed by Genrich Altshuller and his colleagues in the USSR in 1946. Based on an analysis of thousands of product patents, distinct product innovation patterns were identified. These patterns were translated into a set of 40 TRIZ innovation principles, which provide concrete guidance regarding product innovation options. At first sight, *product* innovation principles do not seem to be directly relevant for rethinking care *processes*. However, care processes share several characteristics with products:

- Care processes face numerous synchronization challenges due to the existence of autonomous medical disciplines and specialized departments that require interdisciplinary cooperation and coordination. Products face, to some extent, similar synchronization challenges due to highly interacting product components.
- Care processes often require the physical presence of patients. Similarly, many products process physical objects (e.g. luggage conveyor systems).
- Care processes as well as products typically have to fulfill strict safety regulations.

Due to these three similarities, we argue that the TRIZ innovation principles have the potential to provide new and complementary insights into how care processes can be improved. As far as we know, the set of TRIZ innovation principles has not been used to improve care processes so far. However, several attempts can be found in literature that use the set of 40 TRIZ innovation principles to improve services or processes in other domains (Chai et al. 2005; Wang and Chen 2010). Although promising, a more in-depth investigation of its potential is necessary. In particular, a systematic investigation should reveal whether TRIZ innovation principles (after adaptation to process improvement terminology) provide relevant enhancements for the set of BPR best practices.

4.3.2. Building blocks of RePro application procedure

The application of the set of RePro principles is supported by an application procedure, which describes how the principles can be applied. This procedure is based on the *nominal group technique* (Van de Ven and Delbecq 1974) and the *multi-level design approach*

(Patrício et al. 2011), which were both identified as part of our systematic literature review (see Chapter 2). In this section, we discuss these building blocks in more detail and explain why these two building blocks form the basis of the application procedure.

Nominal group technique

The importance of composing a multi-disciplinary team for rethinking care processes is widely acknowledged (e.g. Caccia-Bava et al. 2005; Shi et al. 2008; Vanhaecht et al. 2009). The involvement of representatives of all relevant disciplines enables generating process improvement ideas for the *whole* care process (e.g. Corbitt et al. 2000; Shi et al. 2008; Talib and Rahman 2010). Moreover, the establishment of such a team makes it easier to build commitment for implementing the generated ideas (e.g. Corbitt et al. 2000; Talib and Rahman 2010). In this realm, it can be considered a weakness that none of the identified rule-based techniques in Chapter 2 contains an explicit procedure about how multiple persons should work together to generate process improvement ideas. The *nominal group technique* offers a potential solution for this void as it offers a procedure for groups of individuals that are faced with an idea generation task. This technique is characterized by silent individual idea generation followed by discussion and voting. Van de Ven and Delbecq (1974) compared this group technique with the Delphi technique and traditional brainstorming. Contrary to prior experiments focusing on an evaluation of the techniques in the context of probability estimation problems, they focused on an evaluation of the techniques with regard to divergent idea generation. The results of their lab experiment show that the nominal group technique and the Delphi technique are significantly more effective than traditional brainstorming in terms of the number of unique ideas generated. In addition, the perceived group satisfaction was significantly higher in the nominal group technique condition than in the two other conditions. Based on these results, Van de Ven and Delbecq (1974) recommend the nominal group technique in situations where people are easily brought together physically.

Multi-level design

Next to enabling multiple persons to work together on the idea generation task, an application procedure of a rule-based technique should also provide a feasible procedure for dealing with the large amount of principles. Attempts have been undertaken to develop an algorithmic approach to generate a prioritized list of principles that are worthwhile to consider (Hanafizadeh et al. 2009; Jansen-Vullers and Reijers 2005; Limam Mansar et al. 2009; Netjes et al. 2008; Nissen 2000; Tsai et al. 2009). Some of the algorithmic approaches require input parameters to be entered by practitioners such as the type of performance improvement dimensions that are most important (Hanafizadeh et al. 2009; Jansen-Vullers and Reijers 2005; Limam Mansar et al. 2009; Tsai et al. 2009). Based on the specification of these input parameters and an a-priori determination of the typical impact of a principle on these dimensions, a prioritized list of principles is generated. Although feasible, assigning weights to different improvement dimensions and other input parameters for a business process redesign project is a highly subjective process. Moreover, it is also not straightforward to determine a-priori which principles typically influence a certain process improvement dimension. Other algorithmic approaches make use of process (weaknesses) measures (e.g. a high percentage of control tasks) in combination with condition statements to come up with a list of relevant principles (Netjes et al. 2008; Nissen 2000). Unfortunately, it turns out to be difficult to identify relevant objective measures for all principles.

Besides the limitations of the algorithmic approaches outlined above, it is also debatable whether the main objective of these approaches targets a highly relevant issue: improving the efficiency of generating process improvement ideas. In many business process redesign projects weeks or months are spent on modeling and analyzing the as-is process, whereas a few hours are typically spent on generating process improvement ideas in a workshop setting. Given this imbalance, it is questionable whether improving the efficiency of generating ideas should be a key objective of a new procedure that supports this task. More important is that the procedure ensures that practitioners do not get overwhelmed by the extensive list of principles and an effective application is facilitated.

An approach that potentially offers this kind of support is the *multi-level design approach* as proposed by Patrício et al. (2011). This approach is not an algorithmic approach that leads to a prioritized list of principles, but an approach assuming that service systems can be designed at different levels of abstraction (Patrício et al. 2011). This approach separates concerns and starts with redesigning the to-be at a relatively high level of abstraction, i.e. the to-be service concept. Subsequently, two lower levels of abstraction related to the to-be process are successively considered. Although such an approach does not necessarily improve the efficiency of generating process improvement ideas, it improves usability by separating concerns.

4.4 Research methodology

In the remainder of this chapter, we outline the development of a new, systematic technique for rethinking care processes: the RePro (Rethinking of Processes) technique. The backbone of this technique is a comprehensive set of RePro principles that has been formed by comparing and integrating the two groups of principles discussed in Section 4.3.1: *BPR best practices* and *TRIZ innovation principles*.

The procedure that was used to systematically compare and integrate the sets of BPR best practices and TRIZ innovation principles was based on the Delphi technique. The Delphi technique is a structured discussion technique which relies on a panel of experts who do not need to be in close physical proximity (Van de Ven and Delbecq 1974). Typically, the technique contains two rounds of questionnaires and anonymous feedback reports in order to reach consensus about a certain topic. The panel experts are encouraged to revise their earlier answers based on feedback reports that include replies of other panel experts.

A Delphi technique with four panel experts was applied in order to compare and integrate the two groups of principles. This Delphi procedure applied contained one preparation step and four discussion steps. The preparation step aimed at obtaining a full understanding of the 29 BPR best practices and 40 TRIZ innovation principles. Regarding the four discussion steps that followed, it was decided to take the set of 29 BPR best practices and related categories as a basis. Because care processes typically contain a large administrative component, it is assumed that all BPR best practices and categories are relevant in the context of care processes. During the four discussion steps, it was determined for each TRIZ innovation principle whether (1) it is already captured by one of the existing BPR best practices, (2) it offers a new relevant principle that can be added to the set of BPR best practices, or (3) it does not offer a principle that is translatable to a *process* improvement principle. Based on this analysis, new principles and related categories were added to the BPR best practices framework in a systematic way. Each of the four discussion steps contained two individual rounds followed by feedback reports and one face-to-face consensus round chaired by the moderator. More details with regard to these steps can be found in Appendix C.1.

After the comparison and integration of the two groups of principles, a procedure was developed to support practitioners in applying the set of RePro principles. As discussed in Section 4.3.2, this application procedure includes the *nominal group technique* and the *multi-level design approach* as core ingredients.

4.5 Results of comparing and integrating principles

The results of the Delphi procedure related to the comparison and integration of TRIZ innovation principles and BPR best practices are briefly summarized below. In the remainder of this section, we discuss the (1) relationships identified between TRIZ innovation principles and BPR best practices (e.g. a TRIZ principle offers a new relevant principle that can be added to the set of BPR best practices), (2) new categories of principles, and (3) additional enhancements for the set of principles. All intermediate results regarding the four steps of the Delphi procedure can be found in (Vanwersch et al. 2014).

Relationships between TRIZ innovation principles and BPR best practices

In Table 4.1, we outline the relationships identified between TRIZ innovation principles and BPR best practices.

Comparison result	*Number of TRIZ innovation principles*
Principle that is already captured by one of the original BPR best practices	18 (45%)
Principle that is not translatable to a process improvement principle	14 (35%)
Principle that is a relevant addition to the original set of BPR best practices	8 (20%)

Table 4.1. Summary comparison TRIZ innovation principles and BPR best practices.

The application of the Delphi procedure revealed that 18 out of 40 TRIZ innovation principles (45%) are already (partially) captured by the BPR best practices. More specifically, we identified 14 “is like” association relationships, three “parent-child” generalization relationships and one “child-parent” generalization relationship. An example of the first kind of relationship is the relationship between the TRIZ innovation principle “extraction” (separate an interfering part or property from an object or system, or single out the only necessary part or property of an object or system) and the BPR best practice “exception” (design processes for typical orders and isolate exceptional orders from normal flow). An example of the second kind of relationship is the relationship between the (parent) TRIZ innovation principle “partial or excessive action” (if 100% of an object or system is hard to achieve using a given solution method, then, by using slightly less or slightly more of the same method, the problem may be considerably easier to solve) and the (child) BPR best practice “extra resources” (if capacity is not sufficient, consider increasing the number of resources).

As part of the Delphi procedure, we also concluded that 14 out of 40 TRIZ innovation principles (35%) are not translatable to a *process* improvement principle. Examples of these principles are “thermal expansion” (use thermal expansion or contraction of materials, or if thermal expansion is being used, use multiple materials with different coefficients of thermal expansion) and “composite materials” (change from uniform to composite materials). These principles are relevant in the context of *product* innovation, but are not translatable to principles that are relevant in the context of improving *processes*.

For eight out of 40 TRIZ innovation principles (20%), we concluded that the TRIZ innovation principle is a relevant addition to the set of BPR best practices. Examples of these TRIZ innovation principles are “prior action” (perform tasks before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process) and “rejecting and regenerating parts / sustainable use” (consider to make use of materials with reusing, dissolving, or evaporating characteristics). The TRIZ innovation principle “prior action” states that the required change of an object should be performed before it is necessarily needed and prearrangements should be taken to ensure that objects or systems can come into action from the most convenient place and without losing time for their delivery (Chai et al. 2005). An example of an application of this principle in healthcare is asking patients to already undress in a preparation room before entering the treatment room. In this way, a medical specialist can immediately start assessing the patient without waiting for the patient to undress. As a result, expensive idle time of the medical specialist is prevented. Similar to “prior action”, the TRIZ innovation principle “rejecting and regenerating parts / sustainable use” offers a relevant addition to the original set of BPR best practices. An example of an application of this principle in the healthcare domain is the usage of self-dissolving stitches to improve the efficiency of the process by eliminating the need for removing the stitch. An overview of all eight principles that we considered relevant additions to the set of BPR best practices is shown in Table 4.2.

Name principle	*Definition*	*Category*
1. Prior counteraction	Add tasks to prevent the occurrence of an undesirable situation or to reduce its impact	Tasks
2. Prior action	Perform tasks before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process	Tasks
3. Periodic action	Consider making an action periodic or changing the periodicity of an already recurrent action	Task order and timing
4. Shortcut	Introduce process shortcut possibilities	Task order and timing
5. Feedback	Consider introducing feedback	Information
6. Sustainable use	Consider to make use of materials with reusing, dissolving, or evaporating characteristics	Facilities, equipment and material
7. Reconstruction	Consider reconstructing the physical lay-out	Physical lay-out
8. Flexible lay-out	Make the physical lay-out flexible	Physical lay-out

Table 4.2. Overview principles added to the original set of BPR best practices.

Identified new categories of principles

As shown in Table 4.2, three TRIZ innovation principles led to the extension of the BPR framework (see Figure 4.1) with two new categories: *facilities, equipment, and material* and *physical lay-out*. The category *facilities, equipment, and material* includes principles that are related to the number and type of available facilities, equipment, and material as well as the allocation of these non-human resources to patients. In contrast to many administrative processes, care processes typically make use of expensive facilities, equipment, and material. Smart usage of these influences process performance in a positive way (e.g. in terms of process' costs and throughput times), such as the usage self-dissolving stitches discussed in the previous paragraph.

The second category, *physical lay-out*, includes principles that focus on the physical arrangement of the process. Typically, rearrangements of the physical lay-out make other kinds of process changes possible. For example, positioning preparation rooms closer to treatments rooms enables productivity gains by moving preparation activities from treatment to preparations rooms. The absence of the physical lay-out category in the original BPR framework can be explained by the fact that digital objects instead of physical objects / clients are typically transferred in the administrative domain. In contrast to physical transfers, digital transfers are not highly influenced by the physical arrangement of the process.

Besides these two additions, we decided to adjust the name of four original BPR framework categories. More precisely, the original BPR framework categories *operation view*, *behavioural view*, *organisation* and *technology* were replaced by the categories *tasks*, *task order and timing*, *human resources* and *information and communication technology* respectively. We considered these new terms to be better aligned with process redesign terminology in the healthcare domain.

Additional enhancements for set of principles

In addition to the eight TRIZ innovation principles and the two new categories that we considered relevant additions to the original set of BPR best practices, we also considered additional enhancements. More specifically, we investigated the TRIZ innovation principles that were in a generalization relationship with a BPR best practice. It was evaluated whether there was added value in adding one of these principles to the set of principles. In case of an addition, a decision was made whether keeping the related child or parent BPR best practice in the existing set of principles was valuable or not. In addition, the panel experts were asked to review whether principles within a certain category could be copied (with a slightly adapted name and / or definition) to another (new) category. Categories are describing process elements which can be addressed during a redesign project and it might be the case that a certain principle is relevant in more than one category. For example, principles that are relevant in the context of human resources might also be relevant in the context of non-human resources.

In total, eight new principles were added to the original set of BPR best practices as part of the procedure specified above. An overview of these principles is shown in Table 4.3. For example, we added two new substitution-related principles to the original set. These additions were based on the identified parent-child relationship between the TRIZ innovation principle "substitution" and the BPR best practice "outsourcing". Next to outsourcing a whole process or parts of it, substituting over-qualified *human* or over-equipped *non-human resources* by less expensive resources are considered to be relevant other redesign opportunities. Apart from adding the eight principles that are shown in Table 4.3, we also changed the "extra resources" principle (if capacity is not sufficient, consider increasing the number of resources) into "resource adjustment (HR)" (consider changing the number of human resources) based on the identified parent-child generalization relationship.

Name principle	*Definition*	*Category*
1. Substitution (HR)	Replace expensive human resources with less expensive ones	Human resources
2. Buffering (NHR)	Consider to buffer equipment and material	Facilities, equipment, and material
3. Flexible assignment (NHR)	Assign non-human resources in such a way that maximal flexibility is preserved for the near future	Facilities, equipment, and material
4. Resource adjustment (NHR)	Consider changing the number of involved non-human resources	Facilities, equipment, and material
5. Specialist-generalist (NHR)	Consider to replace non-human resources with more specialized or more generic-equipped ones	Facilities, equipment, and material
6. Substitution (NHR)	Replace expensive non-human resources with less expensive ones	Facilities, equipment, and material
7. Copying	Consider to use inexpensive copies of non-human resources instead of expensive original ones	Facilities, equipment, and material
8. Physical shortcut	Introduce physical shortcut possibilities	Physical lay-out

Table 4.3. Overview enhancements for set of principles. HR = Human Resources; NHR = Non-Human Resources.

4.6 RePro technique

In this section, we explain the final deliverables of the development phase: (1) the RePro framework containing the categories that are used to classify all RePro principles (2) the RePro principles, and (3) the procedure that supports practitioners in applying the RePro principles.

4.6.1 RePro framework

All RePro principles are assigned to nine categories addressing aspects of a care process that can be improved. In Figure 4.2, we provide an overview of these categories. The newly identified categories as part of the Delphi procedure are highlighted in white.

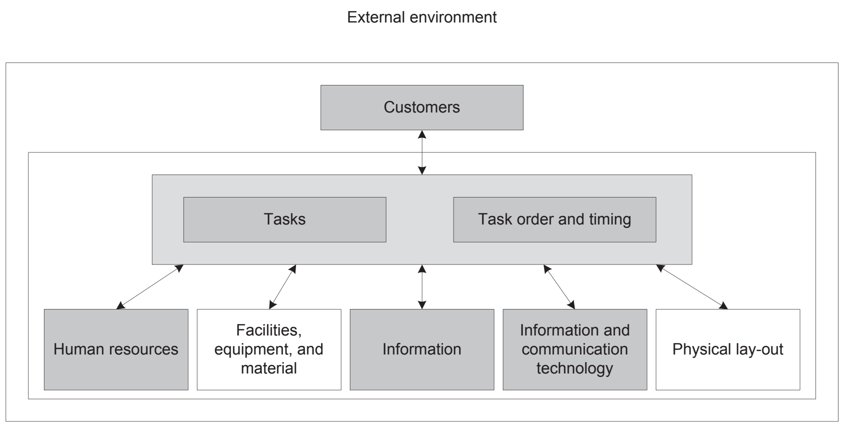


Figure 4.2. RePro framework.

As shown in Figure 4.2, nine RePro categories are distinguished:

- *External environment*: addressing collaboration and communication with third parties;
- *Customers:* focusing on improving contacts with customers;
- *Tasks:* considering the tasks that are part of the process;
- *Task order and timing:* addressing the order in which tasks are executed and the more detailed timing of task execution;
- *Human resources:* considering the number and types of available human resources and

the way they are allocated to tasks;
- *Facilities, equipment and, material*: focusing on the number and types of available facilities, equipment, and material and the way these non-human resources are allocated to tasks;
- *Information:* addressing the way information is used or created;
- *Information and communication technology:* considering how information and communication technology is used;
- *Physical lay-out:* focusing on the physical arrangement of the process.

4.6.2 RePro principles

The comparison and integration of BPR best practices and TRIZ innovation principles led to a total set of 45 RePro principles. The names and definitions of all RePro principles are shown in Table 4.4. A more detailed explanation and application example of each RePro principle can be found in Appendix C.2.

Name principle	*Definition*
Category Customers	
1. Control relocation	Move controls towards the customers (patients).
2. Contact reduction	Reduce the number of contacts with customers (patients) and third parties.
3. Integration	Consider the integration with a process of the customer (patient) or a supplier.
Category External environment	
4. Trusted party	Instead of determining information oneself, use results of a trusted party.
5. Outsourcing	Consider outsourcing a process as a whole or parts of it.
6. Interfacing	Consider a standardized interface with customers (patients) and partners.
Category Tasks	
7. Order types	Determine whether tasks are related to the same type of order (patient group) and, if necessary, distinguish new processes.
8. Task elimination	Eliminate unnecessary tasks from the process.
9. Prior counteraction	Add tasks to prevent the occurrence of an undesirable situation or to reduce its impact.
10. Prior action	Perform tasks before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process.
11. Triage	Consider the division of a general task into two or more alternative tasks or consider the integration of two or more alternative tasks into one general task.
12. Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks.
Category Task order and timing	
13. Order-based work	Consider removing batch-processing and periodic activities from the process.
14. Periodic action	Consider making an action periodic or changing the periodicity of an already recurrent action.
15. Shortcut	Introduce process shortcut possibilities.
16. Resequencing	Move tasks to more appropriate places.
17. Knock-out	Order knock-outs in an increasing order of effort and in a decreasing order of termination probability.
18. Parallelism	Consider whether tasks may be executed in parallel.
19. Exception	Design processes for typical orders (patients) and isolate exceptional orders (patients) from normal flow.
Category Human resources	
20. Order assignment	Let workers perform as many steps as possible for single orders (patients).
21. Customer teams	Consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of orders (patients).
22. Case manager	Appoint one person as responsible for the handling of an order (a patient), the case manager.
23. Flexible assignment (HR)	Assign human resources in such a way that maximal flexibility is preserved for the near future.
24. Centralization	Treat geographically dispersed human resources as if they are centralized.
25. Split responsibilities	Avoid assignment of task responsibilities to people from different functional units.
26. Numerical involvement	Minimize the number of departments, groups, and persons involved in the process.
27. Resource adjustment (HR)	Consider changing the number of human resources.
28. Specialist-generalist (HR)	Consider to make human resources more specialized or more generalist.
29. Empower	Give workers most of the decision-making authority and reduce middle management.
30. Substitution (HR)	Replace expensive human resources with less expensive ones.

Table 4.4. Overview RePro principles. HR = Human Resources; NHR = Non-Human Resources; I = Information.

Name principle	Definition
Category Facilities, equipment, and material	
31. Flexible assignment (NHR)	Assign non-human resources in such a way that maximal flexibility is preserved for the near future.
32. Buffering (NHR)	Consider to buffer equipment and material.
33. Resource adjustment (NHR)	Consider changing the number of non-human resources.
34. Specialist-generalist (NHR)	Consider to replace non-human resources with more specialized or more generic-equipped ones.
35. Substitution (NHR)	Replace expensive non-human resources with less expensive ones.
36. Copying	Consider to use inexpensive copies of non-human resources instead of expensive original ones.
37. Sustainable use	Consider to make use of material with reusable, dissolving, or evaporating characteristics.
Category Information	
38. Control addition	Check the completeness and correctness of incoming materials and check the output before it is send to customers (patients).
39. Buffering (I)	Instead of requesting information from an external source, buffer it by subscribing to updates.
40. Feedback	Consider introducing feedback.
Category Information and communication technology	
41. Task automation	Consider automating tasks.
42. Integral technology	Try to elevate physical constraints in a process by applying new technology.
Category Physical lay-out	
43. Reconstruction	Consider reconstructing the physical lay-out.
44. Flexible lay-out	Make the physical lay-out flexible.
45. Physical shortcut	Introduce physical shortcut possibilities.

Table 4.4 (continued). Overview RePro principles. HR = Human Resources; NHR = Non-Human Resources; I = Information.

4.6.3 RePro application procedure

The application of the set of RePro principles is supported by a procedure that guides practitioners in applying the principles in a systematic way. This application procedure contains the *nominal group technique* and *multi-level design approach* as core ingredients (see Section 4.3.2). A graphical summary of the RePro application procedure is shown in Figure 4.3.

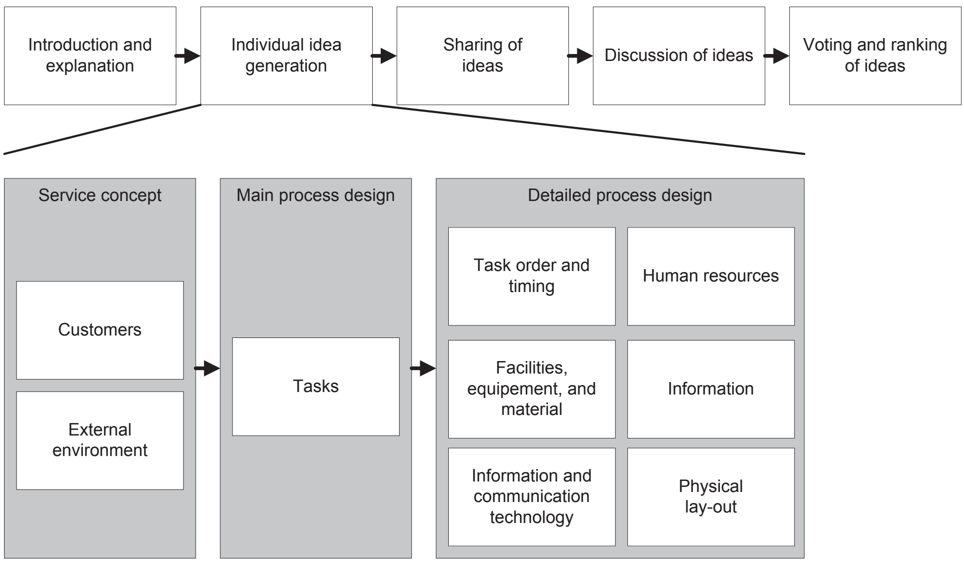


Figure 4.3. RePro application procedure.

As shown in Figure 4.3, the RePro procedure contains five steps that are based on the standard nominal group technique:

- *Introduction and explanation*: The facilitator welcomes the participants and explains to them the objective and procedure of the meeting(s).
- *Individual idea generation:* Each participant in the redesign session is asked to individually generate and write down a list of process improvement ideas based on the RePro principles. The participants are asked not to consult other participants or share ideas with each other. This step is discussed in more detail in the next paragraph.
- *Sharing of ideas:* After each participant has generated a list of process improvement ideas based on a careful consideration of the RePro principles, the facilitator invites the participants to share their process improvement idea and records each idea. This round-robin process continues until all ideas are presented. During this activity, there is still no debate about ideas and participants are invited to write down any new ideas that may arise from what others share.
- *Discussion of ideas:* After all participants have received the opportunity to share their ideas and all ideas are recorded by the facilitator, participants are encouraged to seek verbal or further details about any ideas of other participants that are not clear to them. The facilitator needs to ensure that everybody is able to contribute to the discussion, judgment, and criticism is prevented and no ideas are eliminated. New process improvement ideas might be generated during this activity.
- *Voting and ranking of ideas:* After a final list of ideas is recorded, the ideas are prioritized by the participant using a voting and ranking procedure. Several different voting and ranking processes associated with the nominal group technique can be found in (Delbecq et al. 1975).

During the second step of the RePro procedure, i.e. *individual idea generation*, participants are asked to explicitly consider the set of RePro principles while following the multi-level design approach as shown in the lower part of Figure 4.3. The multi-level design approach implies that all RePro principles are assigned to three levels that can be considered successively:

- *Service concept:* Includes principles that are related to the service concept, i.e. the positioning of the process in relation to its customers and third parties. More specifically, principles at this level focus on improving contacts with customers or try to improve the collaboration and communication with third parties. All principles of the *customers* and *external environment* category are assigned to this level, e.g. “control relocation” (*customers*) and “outsourcing” (*external environment*).
- *Main process design:* Includes principles that are related to the activities that have to be executed in order to fulfill the needs of the customers. The principles of the *tasks* category are assigned to this level. Examples of these principles are “task elimination” and “prior action”.
- *Detailed process design:* Includes principles that are related to the details of task execution, i.e. the “when, who, with what, where” aspects of task execution. Principles belonging to the *task order and timing*, *human resources*, *facilities, equipment, and material*, *information*, *information and communication technology*, and *physical lay-out* category are considered at this level. The “parallelism” (*task order and timing*) and “case manager” (*human resources*) principles are illustrative examples.

Although participants are recommended to consider the three levels successively, iterations between the different levels are allowed. At each level, several RePro principles are available to support practitioners in generating process improvement ideas. For each principle, participants are asked to think about concrete applications, i.e. process improvement ideas related to that principle. After a careful consideration of all principles, the RePro procedure continues with sharing, discussing, and voting and ranking the ideas as discussed in the previous paragraph.

4.7 Summary

Improving the performance of care processes is challenging and requires a well thought-out technique that supports healthcare practitioners in generating process improvement ideas. In this chapter, a new, systematic technique for rethinking care processes is presented: the RePro (Rethinking of Processes) technique. This technique aims to guide practitioners through a more systematic and complete exploration of the full range of process redesign possibilities. Consequently, it is expected that effective process alternatives are more likely to be identified as compared to traditional brainstorming.

The RePro technique supports practitioners in a workshop setting to generate process improvement ideas that mainly at reducing processes' costs and throughput times, as well as improving patient satisfaction. Practitioners can be either external or internal process analysts with an educational background in process management or senior healthcare professionals with a medical background. The backbone of the RePro technique is a set of process improvement principles. This set of process improvement principles constitutes of two core building blocks: *BPR best practices*, which primarily support rethinking administrative processes, and *TRIZ innovation principles,* which in their original form provide support for innovating products. In addition to the set of principles, the RePro technique contains a procedure that guides practitioners in applying the principles. This application procedure includes the nominal group technique and the multi-level design approach as core building blocks.

In the next chapter, we evaluate the core building blocks of the technique in order to fine-tune its design. Towards this end, a cross-case analysis and an applicability check with the two potential end-user groups were conducted.

5

An evaluation and refinement of the design of the RePro technique*

* **This chapter is based on:**
Vanwersch, R.J.B., Pufahl, L., Vanderfeesten, I., Mendling, J., & Reijers, H.A. (2015a). *How suitable is the RePro technique for rethinking care processes?* (Beta working paper no. 468). Eindhoven, NL: Eindhoven University of Technology.

Chapter 5

An evaluation and refinement of the design of the RePro technique

To guide healthcare practitioners in a more systematic and complete exploration of the full range of process redesign possibilities, the Rethinking of Processes (RePro) technique has been introduced in the previous chapter. In this chapter, we evaluate the core building blocks of this technique in order to fine-tune its design. Towards this end, a cross-case analysis and an applicability check with potential end-users of the technique were conducted. The results provide support for the design of the RePro technique. More specifically, the results reveal that the two groups of principles provide complementary insights into how care process can be improved and indicate that the technique provides comprehensive, compact, and well-structured support for rethinking care processes. Nonetheless, several improvements regarding the RePro technique can be identified.

5.1 Introduction

In Chapter 4, we have argued that existing techniques do not provide adequate support for rethinking care processes. As a response, we have introduced the Rethinking of Processes (RePro) technique as a new technique that counterbalances practitioners' tendency to explore only a small fraction of the potential solution space. The backbone of this technique is a set of process improvement principles that is based on the integration of two groups of principles: *BPR best practices*, which primarily support redesigning administrative processes (Reijers and Limam Mansar 2005) and *TRIZ innovation principles*, which in their original form provide support for innovating products (Chai et al. 2005). In addition to the set of principles, the RePro technique includes an application procedure with the *nominal group technique* and the *multi-level design approach* as core ingredients. In this way, the RePro technique aims to provide support for a more complete exploration of the potential solution space as compared to traditional brainstorming.

In this chapter, we evaluate the core building blocks of the RePro technique in order to fine-tune its design. Towards this end, a cross-case analysis and an applicability check with potential end-users of the technique were conducted. The cross-case analysis was executed to gain insights into the implicit usage of the two different groups of RePro principles as well as into the compactness and completeness of the total set of RePro principles. In none of the case studies selected for this purpose, a set of principles was explicitly considered to generate process improvement proposals. However, the process improvement proposals described in these case studies allowed us to determine retrospectively which RePro principles were considered, i.e. were implicitly applied. The applicability check with potential end-users was used to identify additional opportunities for improving the compactness and completeness of the set of RePro principles. Also, possibilities for improving the understandability and expected impact of the RePro principles were investigated. Finally, the applicability check was used to evaluate the core ingredients of the application procedure in order to identify improvement directions for this procedure.

This chapter is structured as follows. Section 5.2 describes the research methodology outlining the procedures followed while executing the cross-case analysis and applicability check. In Section 5.3, we present the results of both research methods. In Section 5.4, the main findings and limitations are discussed and Section 5.5 summarizes this chapter.

5.2 Research methodology

To evaluate the core building blocks of the RePro technique and refine its design, two complementary research methods were used: a cross-case analysis and an applicability check. For both methods, we employed a detailed research protocol. Both protocols are available in (Vanwersch et al. 2015a). In this section, we provide a brief summary of these protocols.

5.2.1 Procedure cross-case analysis

As discussed in the introduction section, we conducted the cross-case analysis to evaluate the implicit usage of the two groups of RePro principles as well as the compactness (i.e. the proportion of principles that are applied) and completeness of the total set of RePro principles. Below, we briefly describe the search and selection procedure as well as the data extraction and coding procedure of the cross-case analysis.

Search and selection

A systematic search and selection procedure was independently executed by two reviewers to identify case studies that included detailed descriptions of process improvement proposals. We decided to focus on case studies that aimed at improving perioperative processes. These processes consist of the steps that are performed just before, during, and after surgery. Besides the fact that these high-volume and high-cost processes are often the object of redesign in healthcare, perioperative processes are also characterized by many synchronization challenges, intensive patient involvement throughout the process, and a large amount of safety requirements (Cardoen et al. 2010). Hence, perioperative processes are a suitable basis for investigating the set of RePro principles and identifying missing principles.

The electronic databases Medline, ABI/Inform, and INSPEC were used to provide coverage of the three relevant research domains. In order to create an extensive Boolean search expression for each electronic database, we systematically investigated synonyms, acronyms, and abbreviations related to the terms “process”, “redesign”, and “perioperative” (see Appendix D.1). We complemented this Boolean expression with database-specific headings. To identify high quality studies efficiently, only peer-reviewed journal articles and conference papers were targeted in line with recommendations of Rowley and Slack (2004) and Webster and Watson (2002). In addition, we only considered articles in English, containing an abstract, and published after 1990.

Analogously to the systematic literature review discussed in Chapter 2 and the cross-case analysis in Chapter 3, two reviewers independently performed a two-stage relevance screening and a quality screening to select relevant and high quality studies. All relevance and quality screening activities were based on detailed inclusion and exclusion criteria (see Appendix B.2). As part of the relevance screening, we checked whether the study reported about an initiative in a *real-life* context. This implies that, for example, artificial simulation studies were excluded. As part of the quality screening, it was checked whether the study provided a clear description of process improvement proposals. We assessed inter-rater-agreement with regard to all screening activities by means of the Kappa statistic (Fink 2010). Any disagreements were resolved by consensus.

Data extraction and coding

After identification of the set of case studies, two reviewers independently extracted process improvement proposals from these studies using a detailed data extraction form (see Appendix D.3). After reaching consensus on data extraction, the reviewers independently coded the process improvement proposals. More precisely, each reviewer assigned to each proposal one or more RePro principles that were implicitly applied to generate the improvement proposal. For example, to the extracted improvement proposal “implement an OR dashboard tool for continuous performance measurement and efficiency monitoring” (Schubnell et al. 2008), the “feedback” and “integral technology” principle were assigned. In case no clear assignment to an existing RePro principle was possible, a new principle was considered to be formed and assigned to the improvement proposal. Data coding discrepancies were discussed by the two reviewers and resolved by consensus.

In addition to extracting process improvement proposals from the studies, several case study characteristics were extracted to obtain insights into the kind of process redesign initiatives covered. These characteristics are (1) the label used by the authors to refer to business process redesign, (2) the country where the initiative took place, and (3) the annual patient volume of the patient group that was the subject of investigation.

5.2.2 Procedure applicability check

Rosemann and Vessey (2008) define applicability checks as “evaluations by practice of theories, models, frameworks, processes, technical artifacts, or other theoretically based IS artifacts that the academic community either uses or produces in its research”. Our applicability check was conducted to identify additional opportunities for improving and extending the total set of RePro principles. Furthermore, our applicability check was used to evaluate the core ingredients of the application procedure in order to fine-tune its design. In order to achieve these objectives, exercise sessions and focus group discussion sessions with a pilot group and two different end-user groups of the technique were conducted: seven nurses involved in redesigning care processes and seven external consultants. Participants were not randomly selected. Instead, a convenient sample of consultants and nurses was recruited. For both end-user groups, it was verified whether all participants had experience in rethinking care processes. In this way, we ensured that all of them could rely on actual experiences to identify improvement directions for the RePro technique. The group of seven external consultants was conveniently recruited based on the list of companies that participated in field study among consultancy firms (see Chapter 3). The average age of the participating consultants was 36.57 years (std: 12.00) and about 29% of them was female. The consultants had on average 8.46 years of experience in rethinking processes (std: 9.84). On average 2.51 years of this experience was directly related to care processes (std: 2.19). The group of seven nurses was a convenient sample of nurses of a Dutch hospital. Their average age was 46.58 years (std: 7.78) and about 71% of them was female. On average they had 6.00 years of experience in rethinking processes (std: 3.00). 5.57 years of this experience was on average directly related to care processes (std: 2.88).

For the different groups of participants, separate exercise sessions and focus groups were organized. During the 2-hours exercise sessions, every individual participant was asked to rank the RePro principles regarding their understandability and their expected impact using a Q-sort procedure (Ponsignon and Smart 2013; Tractinsky and Jarvenpaa 1995; Watts and Stenner 2005), which is discussed in more detail in the protocol in (Vanwersch et al. 2015a). The exercise session ensured that participants were familiar with the set of RePro principles before examining issues in a face-to-face focus group discussion. Moreover, both ranking procedures included several follow-up questions (e.g. providing examples and reasoning for low and high ranked items), which provided input for the focus group discussion sessions. During the 1.5 hours follow-up focus group sessions, we discussed concrete possibilities for improving the understandability, expected impact, compactness and completeness of the RePro principles. Furthermore, we evaluated the core ingredients of the application procedure and discussed related improvement directions regarding this procedure. A research assistant took notes during the audio-taped focus group discussion. After the focus group discussion, the audio tapes were transcribed by the research assistant. These transcriptions were checked by the moderator of the sessions. Subsequently, both researchers discussed the transcriptions and summarized the main findings.

More detailed information about the set-up of the exercise and focus group discussion sessions can be found in the applicability check protocol (Vanwersch et al. 2015a).

5.3 Results

This section presents the results of the cross-case analysis and the applicability check.

5.3.1 Results cross-case analysis

Below, we start with explaining the search and selection results of the cross-case analysis. Subsequently, we present the data extraction and coding results with regard to the *case study characteristics* and the *process improvement proposals*.

Search and selection results

The search and selection results regarding the cross-case analysis are graphically summarized in Figure 5.1.

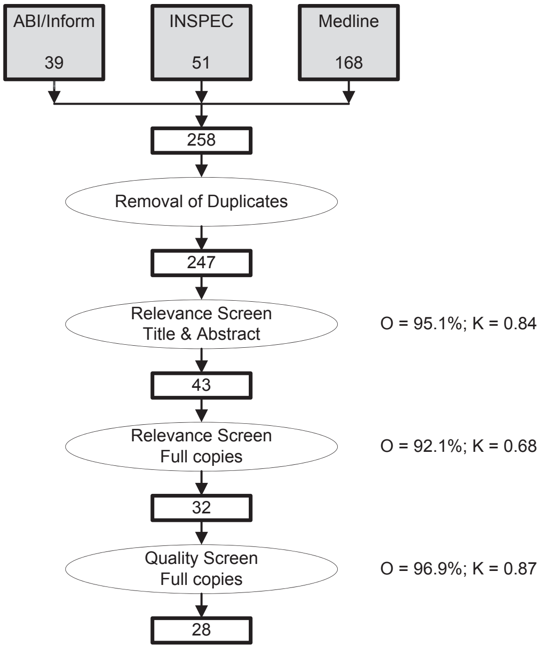


Figure 5.1. Flowchart search and selection results cross-case analysis.
O = Observed agreement; K = Kappa statistic.

By means of the electronic and manual search, we retrieved 258 non-duplicate articles. 28 out of these 258 studies passed the two-stage relevance screening and quality screening. For all relevance and quality screening activities, inter-rater-agreement, as determined by Kappa statistics, varies between substantial and almost perfect agreement (min Kappa = 0.68; max Kappa = 0.87).

Data extraction and coding results

Case study characteristics

The set of studies consists of 24 journal papers (86%) and four conference papers (14%). Table 5.1 includes more information with regard to the characteristics of the selected studies.

Case study characteristic		*No. of case studies*	*Perc. of case studies*
Label	Six Sigma	3	11%
	Lean & Six Sigma	2	7%
	Business Process Management (BPM)	1	4%
	Business Process Reengineering (BPR)	1	4%
	Lean	1	4%
	No label	20	71%
Country	USA	17	61%
	Australia	2	7%
	Germany	2	7%
	Chile	1	4%
	China	1	4%
	Singapore	1	4%
	The Netherlands	1	4%
	UK	1	4%
	Multiple countries	1	4%
	Not specified	1	4%
Annual patient volume	1-100 patient visits per year	0	0%
	101-1.000 patient visits per year	4	14%
	1.001-10.000 patient visits per year	9	32%
	>10.000 patient visits per year	5	18%
	Not specified	10	36%

Table 5.1. Case study characteristics of cross-case analysis.

Table 5.1 shows that five different *labels* were used by the authors of the case studies to refer to the redesign of business processes. The most popular label assigned is Six Sigma (11%). The selected process redesign initiatives were executed in 10 different *countries*. A large majority of initiatives took place in the United States (61%). Finally, Table 5.1 indicates that the *annual patient volumes* of the patient groups that were the subject of investigation cover a wide range of volumes. The categories “101-1.000”, “1001-10.000”, and “>10.000” patient visits per year” are all represented by a number of studies. A detailed overview of all case study characteristics per study is available as an online report[5].

Process improvement proposals

The selected 28 case studies include 134 (perioperative) process improvement proposals. All 134 process improvement proposals were assigned to implicitly used principles by two reviewers. Inter-rater-reliability was determined by calculating the percentage of process improvement proposals that were assigned to the same principle(s) by the two reviewers. This percentage of agreement is 87%. After reaching consensus on all assignments, the outcomes were as follows. The coding of the 134 process improvement proposals resulted in 168 assignments to implicitly used principles. 129 out of 134 (96%) process improvement proposals were linked to the implicit usage of at least one RePro principle (i.e. 99 one-principle assignments, 26 two-principles assignments, and 4 three-principles assignments were the result of the coding procedure). The remaining 5 process improvement proposals were assigned to a newly identified principle. An overview of all assignments per study is available as an online report[6]. In the remainder of this section, we investigate the implicit usage of the RePro principles and discuss the newly identified principle.

[5] https://robvanwersch.files.wordpress.com/2016/01/study-characteristic-codings-per-study-cca-ch-5.xlsx
[6] https://robvanwersch.files.wordpress.com/2016/01/codings-process-improvement-proposals-per-study-cca-ch-5.xlsx

Usage of RePro principles

Table 5.2 zooms in on the implicit usage of individual RePro principles in the selected sample of case studies. This table displays the *five most often* applied principles. An overview of the implicit usage of all RePro principles can be found in Appendix D.4.

RePro principle (BPR / TRIZ)	*Definition principle*	*RePro category*	*Application example Principle*	*No. of implicit application of principles*
10. Prior action *(TRIZ)*	Perform tasks before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process	Tasks	For subsequent surgical cases, nonsurgical tasks normally performed in the OR are completed concurrent with the ongoing case (Cima et al. 2011).	19
42. Integral technology *(BPR)*	Try to elevate physical constraints in a business process by applying new technology	ICT	Provide physicians with online access to the surgery schedule (Schubnell et al. 2008).	18
28. Specialist-generalist (HR) *(BPR)*	Consider to make human resources more specialized or more generalist	Human resources	The reception nurse is cross-trained to support nurses involved in transfers of patients during idle time (Barkaoui et al. 2002).	17
34. Specialist-generalist (NHR) *(TRIZ)*	Consider to replace non-human resources with more specialized or more generic-equipped ones	Facilities, equipment, and material	Make use of a standard instrument setup for cardiac cases (Krasner et al. 1999).	13
43. Reconstruction *(TRIZ)*	Consider reconstructing the physical lay-out	Physical lay-out	Create a separate preparation room adjacent to the OR theatre for anaesthesia (Meredith et al. 2011).	13

Table 5.2. Five most often implicitly applied RePro principles.

In Table 5.2, we distinguish between BPR best practices (BPR) and the principles that we added as part of the TRIZ-related integration procedure (TRIZ). Table 5.2 reveals that the TRIZ-related principle "prior action", which belongs to the tasks category, is applied in the highest number of case studies. This principle states: "perform tasks, before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process". In total, this RePro principle is in 19 times implicitly applied to generate a process improvement idea in the selected sample of case studies. An example of an implicit application of the "prior action" principle is completing all nonsurgical tasks prior to moving a patient to the operation room (Cima et al. 2011). In this way, a more effective utilization of operation rooms is achieved. Other TRIZ-related RePro principles with a high implicit usage are "specialist-generalist" (*facilities, equipment, and materia*l) and "reconstruction" (*physical lay-out*). Together with the BPR best practices "specialist-generalist" (*human resources*) and "integral technology" (*information and communication technology*), these principles complete the top 5 most often applied principles.

In Figure 5.2 and Figure 5.3, we provide more insights into the implicit usage of the two groups of principles. In these figures, we distinguish between BPR best practices and TRIZ-related principles as well as between the different RePro categories. In Figure 5.2, the numbers in the bars refer to the identification numbers of the RePro principles. These identification numbers are also used in Table 4.4 (Overview RePro principles), Appendix C.2 (Detailed overview of RePro principles), and Appendix D.4 (Implicit usage of RePro principles).

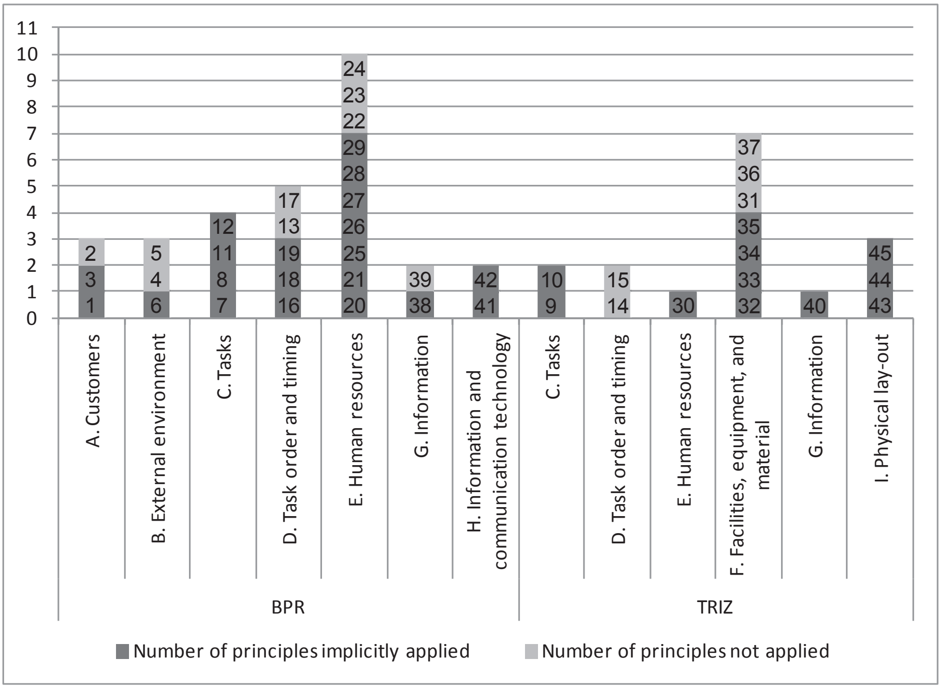


Figure 5.2. Number of principles implicitly applied by at least one case study (per category and group).

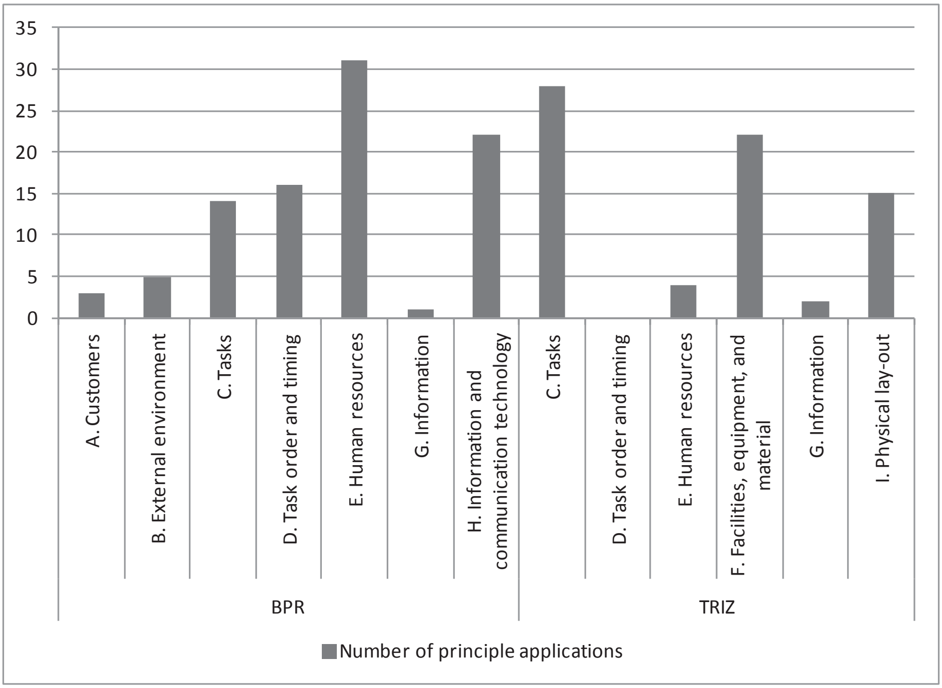


Figure 5.3. Number of RePro principle applications (per category and group).

Figure 5.2 shows that the large majority of both groups of principles are implicitly applied in at least one case study. More specifically, the sample of case studies covers 20 out of 29 principles (69%) of the set of BPR best practices. Similarly, 11 out of 16 (69%) of the principles that we added as part of the TRIZ-related integration procedure are covered by the sample of case studies. The results per RePro category in Figure 5.2 also suggest that the two categories that we added as part of the TRIZ-related integration procedure, i.e. *facilities, equipment, and material* (FEM) and *physical lay-out* (PL), are relevant enhancements. Four out of seven (57%) FEM principles and three out of three (100%) PL principles are applied in at least one case study.

In Figure 5.3, we show the total number of principle applications per category and per group. Figure 5.3 reveals that the selected sample of case studies contains 92 applications of BPR best practices and 71 applications of TRIZ-related principles. Although these results indicate that the total implicit usage of the BPR best practices is higher than the TRIZ-related principles, this difference is not proportional to the number of principles that are part of this group. Note that the set of RePro principles contains 29 original BPR best practices and 16 TRIZ-related principles. In fact, the average implicit usage per principle is higher for the TRIZ-related principles: 4.44 applications per principle versus 3.17 applications per principle for the BPR best practices. In particular, the TRIZ-related principles of the *task* (e.g. “prior action” and “prior counteraction”), *facilities, equipment, and material* (e.g. “specialist-generalist (NHR)” and “resource-adjustment (NHR)”), and *physical lay-out* (e.g. “reconstruction”) category are frequently applied.

Overall, the implicit usage results indicate that the two groups of principles provide complementary insights into how care processes can be improved. Furthermore, the results indicate that the total set of RePro principles provides almost complete coverage of frequently, yet implicitly applied principles and is compact at the same time (i.e. the number of principles without any implicit applications is limited). These findings provide support for our design choice to integrate the two groups of principles and suggest that there is potential for an explicit consideration of RePro principles in process redesign projects in healthcare.

Identification of new principles

As stated, only five out of 134 coded improvement proposals are not captured by one of the 45 RePro principles. These five improvement proposals are shown in Table 5.3.

Study	*Process improvement proposal*
Bahlman and Johnson (2005)	“Other quality improvement initiatives included providing patients’ family members with up-to-date information regarding anticipated delays, how long the patient is in a specific area, or when procedure completion is expected.”
Caplan et al. (1998)	“Improved patient educational material was developed for distribution by the surgeons.”
Heinzelman (1996)	“We found patients were not given enough information regarding their surgical experience to keep them abreast of what was happening and why it was happening. Our consumer research revealed that patients select specific surgeons and procedures far more often than in the past. Given this information, we decided to improve our patient education. When a patient decides to have surgery, he or she now receives a pamphlet about his/ her future procedure at the surgeon's office.”
Heyrman et al. (1995)	“Patient education: improve educational materials and produce a video that introduces patients to the perioperative experience.”
Sedlack (2010)	“.... and improved preoperative patient education.”

Table 5.3. Process improvement proposals not captured by one of the 45 RePro principles.

The five improvement proposals, as shown in Table 5.3, led to identification of one new RePro principle.

Information provision (category *information*): This principle states that one should consider providing additional information to customers. Particularly, it is recommended to inform patients about diagnostic and treatment activities that are going to happen as well as the reason for executing them. This principle aims to improve the quality of the process as perceived by customers. An example of an application of this principle is giving patients access to a video that introduces them to the perioperative experience (Heyrman et al. 1995).

5.3.2 Results applicability check

The cross-case analysis focused on the implicit usage of different groups of RePro principles. The applicability check was conducted to gain more in-depth insights into and improve the explicit application potential of the RePro principles. In the remainder of this section, we explain several proposed adjustments with regard to the set of RePro principles. Furthermore, we discuss the end-users remarks regarding the core building blocks of the application procedure and outline related improvement directions.

Adjustments regarding RePro principles

The exercise sessions and follow-up focus group discussion sessions made clear that none of the principles is considered to be irrelevant or without value. However, some fine-tuning regarding the description of several RePro principles was desirable to enable an effective uptake in process redesign projects in healthcare. Small textual adjustments were made with regard to ten RePro principles (six BPR best practices and four TRIZ-related principles). For example, we changed the name and definition of the centralization principle (treat geographically dispersed human resources as if they are centralized) into geographic centralization (arrange technological support to enable effective collaboration of geographically dispersed human resources). This adjustment was made to prevent confusion with the frequently applied centralization that aims at keeping all decision-making powers within the head office or the centre of the organization.

Besides ten textual adjustments, we also introduced two changes that were related to the content of the principles:

Substitution (categories *human resources* and *facilities, equipment, and material*): The original definitions of the TRIZ-related substitution principles state that one should consider replacing expensive human and non-human resources with less expensive ones. The premise of these principles is that resources are often over-qualified or over-equipped for the tasks to be executed. Consequently, cost savings are possible by hiring / procuring less expensive resources that are less qualified or less equipped. During the focus group discussion sessions, we concluded that an exclusive focus on substituting expensive resources by less expensive ones can result in a situation of being “penny wise, pound foolish”. Moreover, the opposite variant of the substitution principle is worth consideration in many situations. The extra labour costs of more qualified employees might be easily recouped by faster task execution or less rework. Furthermore, recruiting more qualified employees might lead to additional efficiency gains (e.g. set-up time reductions) due to increasing possibilities for combining small tasks into larger composite tasks that are executed by the same, more qualified employee. Based on this reasoning, the substitution (HR) principle was changed into "consider replacing expensive human resources with less expensive ones when human resources are over-qualified for tasks to be executed and consider replacing poorly-performing human resources with more expensive and more qualified ones in order to improve process performance". Similarly, the substitution (NHR) principle was changed into "consider replacing expensive non-human resources with less expensive ones when non-human resources are over-equipped for the tasks to be executed and consider replacing under-equipped non-human resources with more expensive and more equipped ones in order to improve process performance".

Interfacing (category *external environment*): The original definition of the BPR best practice interfacing states: "consider a standardized interface with customers and partners". The idea behind this principle is that a standardized interface with customers and partners will diminish the probability of mistakes, incomplete applications and unintelligible communications. Consequently, a standardized interface may result in fewer errors, faster processing, and less rework. During the focus group discussion sessions, we agreed that these advantages do not only apply to information transfers with customers and partners, but also to internal information transfers between employees. Consequently, we decided to change the definition of this principle into: "consider a standardized interface for information transfers". This change was complemented with moving the principle from the *external environment* to the *information* category and rephrasing the explanation of the principle.

Beyond these adjustments, the group of nurses and the group of external consultants agreed that the set of RePro principles provides adequate coverage of frequently, yet implicitly applied principles in healthcare.

An overview of the adjusted RePro principles is shown in Appendix D.5. The complete set of RePro principles including all adjustments can be found in Appendix D.6.

Improvement directions with regard to RePro application procedure

In addition to the set of RePro principles, the core ingredients of the RePro application procedure were evaluated during the focus group discussion sessions with nurses and external consultants. In all groups, the participants reached consensus about the positive influence of using the multi-level design approach to facilitate the explicit consideration of RePro principles. One of the external consultants stated the key advantage of the multi-level design approach as follows: "Splitting up the principles in different levels is certainly valuable. In this way, manageable subsets of principles are created". Similarly, one of the nurses noted: "It seems to be a lot of work for an individual to go through all the principles. Splitting up the principles in different chunks makes application feasible." Also, both groups reached consensus about the appropriateness of following the different steps of the nominal group technique. Three external consultants highlighted the similarities with the approach they were using for rethinking processes: "It resembles the standard workshop approach we are using". In line with this observation, one of the nurses noted: "In fact, it is a more formalized and systematic version of the brainstorming approach we are typically using to generate improvement ideas.”

In addition to these remarks, which provide support for the core building blocks of the RePro application procedure, the group of external consultants argued that it is worthwhile to consider several variants on the proposed application procedure:

Variant 1: Instead of inviting individual participants, install teams of two persons to generate process improvement ideas. According to the consultants, this variant offers more possibilities for social interaction and might have a positive influence on task motivation.
Variant 2: Split the level “detailed process redesign” (see Figure 1) into two or more chunks of related categories, which can be considered by different groups of individuals. This variant separates concerns even more and might prevent individuals from being overwhelmed by a wide variety of process improvement principles.

5.4 Discussion

The results of both evaluation methods, i.e. the cross-case analysis and the applicability check, provide support for the initial design of the RePro technique. Firstly, the cross-case results reveal that BPR best practices and TRIZ innovation principles provide complementary insights into how care processes can be improved. For example, BPR best practices focus more strongly than TRIZ innovation principles on improving the way human resources are allocated to tasks. On the other hand, TRIZ-related principles focus on improving the physical lay-out of the process as well as the way facilities, equipment, and material are used in the process. Both aspects turn out be relevant in the context of rethinking care processes, but were not covered by the BPR best practices. In this way, support is found for our design choice to integrate two groups of principles that are rooted in two different domains, i.e. the administrative domain and the product innovation domain. When adopting a broader perspective, this finding underlines the value of cross-domain research and encourages advocates of a single management philosophy (e.g. Business Process Re-engineering adepts) to broaden their field of interest to related philosophies in different domains.

Secondly, the results of the cross-case analysis and applicability check suggest that the RePro technique provides comprehensive, compact, and well-structured support for rethinking care processes. Based on this finding, we contend that the RePro technique, especially after the refinement of the set of RePro principles in this chapter, is an attractive alternative for traditional creativity, case-based, and repository-based techniques. Further research is needed to elaborate on different application procedures of the RePro technique and to investigate the benefits of the RePro technique as compared to its alternatives. As a first step towards investigating the benefits of the RePro technique, we compare the performance of the RePro technique and traditional brainstorming using an experimental research redesign in the next chapter.

Limitations

Inevitably, there are some limitations to our work. Firstly, the cross-case analysis includes only improvement initiatives targeting perioperative processes. Also, the nurses who participated in the applicability check were mainly involved in executing activities that are part of these processes. Perioperative processes are, given their characteristics, a suitable basis for evaluating the RePro technique. However, the bias towards these processes implies that adequate support for other types of care processes, e.g. diagnostic pathways in an outpatient setting, can be further established by extending our evaluations to these processes.

Secondly, we are aware of a potential confirmation bias as a result of the fact that one of the developers of the RePro technique was also involved in the execution of the cross-case analysis and applicability check. In order to reduce this risk, all coding activities with regard to the cross-case analysis were independently executed by a second reviewer and inter-rater-reliability was measured. Regarding the applicability check, the audio tapes were transcribed and coded by a reviewer that had not been involved in the design of the technique. In addition to these measures, we are fully transparent with regard to all coding results and all research procedures. This makes it possible to verify our findings or even replicate our procedures.

5.5 Summary

In this chapter, the design of the RePro technique is improved based on an evaluation of its core building blocks. A cross-case analysis and applicability check with potential end-user groups were executed towards this end. The evaluation results reveal that BPR best practices and TRIZ-related principles provide complementary insights into how care processes can be improved. Furthermore, the results suggest that the RePro technique provides comprehensive, compact, and well-structured support for rethinking care processes. Notwithstanding the support for the initial design of the RePro technique, the cross-case analysis and applicability check enabled us to refine the set of RePro principles. Moreover, further research is required to elaborate on different application procedures of the RePro technique as well as to investigate the benefits of the RePro technique as compared to its alternatives, such as traditional brainstorming.

In the next chapter, we focus on the latter challenge as it provides important insights for further development purposes. In particular, we present the results of two lab experiments. In both lab experiments, we compare the performance of the RePro technique and traditional brainstorming on several outcome measures, such as the number, diversity, and originality of ideas generated. The RePro technique applied in these experiments includes the refined set of RePro principles.

6

An experimental evaluation of the RePro technique*

* **Parts of the results in this chapter have been published as a conference paper:**
Vanwersch R.J.B., Vanderfeesten, I., Rietzschel, E., & Reijers, H.A. (2015b). Improving business processes: Does anybody have an idea? In H.R. Motahari-Nezhad, J. Recker, & M. Weidlich (Ed.), *Business Process Management*. Paper presented at the 13th International Conference on Business Process Management, Innsbruck, Aug 31 - Sep 3 2015 (pp. 3-18). Berlin: Springer.

Chapter 6

An experimental evaluation of the RePro technique

In the previous chapter, we have evaluated the core building blocks of the Rethinking of Processes (RePro) technique in order to improve its design. In this chapter, we obtain more insights into the benefits of applying the RePro technique as compared to traditional brainstorming. For this purpose, two controlled lab experiments were carried out. Both experiments had a similar set-up, but the recruited participants differed. Experiment participants were graduate students in Industrial Engineering and Nursing & Midwifery respectively. The results of both experiments confirm the potential for using the RePro technique during process redesign workshops, but also suggest that the way the RePro technique is used strongly affects its performance.

6.1 Introduction

The cross-case analysis and the applicability check with potential end-users, as discussed in the previous chapter, suggest that the RePro technique provides comprehensive, compact, and well-structured support for rethinking care processes. Nonetheless, we have not obtained detailed insights into the benefits of explicitly applying the technique in terms of outcome measures, such as the number, diversity, and originality of ideas generated.

To gain more insights into the benefits of the technique, experiments offer interesting opportunities for a rigorous evaluation (Hevner et al. 2004). As discussed in Chapter 2, many studies that introduce a new technique for generating process improvement ideas do not include an evaluation mechanism or only provide an illustration of how the technique can be applied. Only a relatively small number of studies (e.g. Chai et al. 2005; Nissen 2000; Shahzad and Giannoulis 2011) includes a case study investigating the application of the technique in practice. These case studies include an evaluation of the technique, but lack possibilities for comparing the performance of the applied technique with the performance of competing techniques, such as traditional brainstorming. Consequently, benefits attributable to the technique are still hard to determine. A lab experiment offers an attractive alternative for a traditional case study, as it enables a more rigorous evaluation of the benefits attributable to process improvement techniques in a controlled setting. Although conducting lab experiments is getting more common in the area of process modeling (e.g. Kolb et al. 2014; Weber et al. 2014), we are the first to report on lab experiments in the area of generating process improvement ideas.

In this chapter, we present the results of two lab experiments. In both lab experiments, we evaluate the RePro technique and compare its performance with traditional brainstorming. The latter technique seems to be still the most often applied technique in practice to rethink care processes (see Chapter 3). There are four basic rules in traditional brainstorming: (1) go for quantity, (2) withhold (self-)criticism, (3) welcome wild ideas, and (4) combine and improve ideas (Osborn 1953). All these rules rely on the assumption that quantity breeds quality, i.e. the higher the number of ideas generated, the greater the chance of finding effective solutions. In this chapter, we compare the performance of the RePro technique and traditional brainstorming with regard to *individual idea generation*. This step is considered to be a crucial step as it determines the ideas that will be shared, discussed, ranked, and implemented later on (see Figure 4.3 in Chapter 4). Moreover, this step most clearly distinguishes the RePro technique from other techniques, such as traditional brainstorming. For the sake of brevity, we use the term *RePro technique* to refer to this second step of the technique in the remainder of this chapter.

As part of the experiments, participants had to generate process improvement ideas for a cataract surgery process based on a realistic case description. The two lab experiments had a similar set-up. However, the recruited participants differed. The first experiment was carried out with 89 graduate students in Industrial Engineering. In the second experiment, 72 graduate students in Nursing & Midwifery participated.

This chapter is structured as follows. Section 6.2 outlines the expected effects of using the RePro technique. It also includes our hypotheses. In Section 6.3, the set-up of the experiments is explained. Section 6.4 presents the results of the experiments and Section 6.5 discusses the findings and limitations of our work. Section 6.6 summarizes this chapter.

6.2 Hypotheses

By offering a list of categorized process improvement principles, the RePro technique can be expected to influence the outcomes of redesign workshops. In particular, we expect that the application of the RePro technique has an impact on the following typical outcome measures of redesign workshops: productivity (i.e. the number of unique process improvement ideas generated by each individual), diversity, quality, and originality of ideas generated. Moreover, we expect an impact on participants' satisfaction with and intention to use the technique. In the remainder of this section, we outline the related hypothesis and substantiate these with findings from prior studies.

Productivity, diversity, quality, and originality

Previous research reveals that individuals presented with an all-encompassing problem tend to explore only a small fraction of the potential solution space (e.g. Coskun et al. 2000; Dennis et al. 1996; Gettys et al. 1987; Rietzschel et al. 2007). This is caused by people's tendency to not leave the path of least resistance and reproduce slightly modified or even unmodified ideas that can be directly retrieved from memory (Rietzschel et al. 2007). As a result, key solution opportunities are missed. For example, unaided participants missed on average more than half of the solution categories while generating solutions for a parking as well as a housing problem (Gettys et al. 1987).

Several studies show that problem decomposition into multiple categories might decrease the inclination to explore a small number of dominant solution categories. In the context of a natural environment problem (Nijstad et al. 2002), individuals who received stimulation ideas from a diverse range of solution categories outperformed unaided participants in terms of the diversity and number of ideas generated. In line with expectations, diverse stimuli seem to increase the range of accessible knowledge and allow for the generation of more diverse ideas (Nijstad et al. 2002). The observed productivity effect in this study might be attributable to the fact that diverse stimuli prevent individuals from completely running out of ideas at an early stage. In a follow-up analysis, Nijstad et al. (2002) also found another mechanism responsible for the productivity effect. The researchers observed that unaided participants needed on average significantly more time for a category change (the next idea is from a different solution category) than for a category repetition (the next idea is from the same solution category). For participants receiving stimuli, this difference was not found. It appeared that stimulation ideas reduce the time for a category change to the level of a category repetition.

In line with the productivity effect observed by Nijstad et al. (2002), Coskun et al. (2000) found that individuals receiving ten potential solution categories were more productive than unaided participants when generating ideas for improving their university. Also, the participants who received ten potential solutions categories generated more ideas than participants who only received two solution categories

The RePro technique also offers diverse stimulation ideas in the form of categorized RePro principles. Hence, we expect that individuals using the RePro technique are able to generate a larger number of and more diverse ideas as compared to individual brainstormers, i.e. individuals following the four brainstorming rules mentioned earlier.

Hypothesis 1: *The RePro technique supports individuals in generating* ***more*** *ideas as compared to traditional brainstorming.*

Hypothesis 2: *The RePro technique supports individuals in generating* ***more diverse*** *ideas as compared to traditional brainstorming.*

Prior research in the area of creative idea generation has found a strong positive correlation between the number of ideas and the *number of high-quality* ideas (Stroebe et al. 2010). Therefore, we also expect that individuals using the RePro technique are able to generate more high-quality ideas as compared to individual brainstormers.

Hypothesis 3: *The RePro technique supports individuals in generating* ***more high-quality*** *ideas as compared to traditional brainstorming.*

Previous research indicates that concrete idea examples may constrain the subsequent ideas generated by individuals (Smith et al. 1993). More precisely, generated ideas seem to conform to features of examples given prior to a design task (Smith et al. 1993).

In a more recent study (Daly et al. 2012), individuals received design heuristics accompanied with application examples prior to a product design task. These design heuristics were conceptually similar to RePro principles, i.e. also contained a title, a definition, an explanation and an example. The results of this study indicate that multiple applications of the same design heuristic do not yield prescribed solutions. The researchers concluded that these results support the level of specificity of heuristics, suggesting that heuristics support exploration without limiting possibilities, i.e. without a negative impact on the originality of ideas generated. This finding suggest that a conformity effect, as discussed by Smith et al. (1993), is absent when concrete application examples are accompanied with heuristics that provide more generic redesign guidance.

Given the predicted productivity effect and the expected absence of a conformity effect, we predict that individuals using the RePro technique are able to generate more original ideas as compared to individual brainstormers.

Hypothesis 4: *The RePro technique supports individuals in generating* ***more original*** *ideas as compared to traditional brainstorming.*

Satisfaction with and intention to use the technique

Prior research that gives insights into the potential effects of the RePro technique on satisfaction and intention to use is limited to case studies. Shahzad and Giannoulis (2011) evaluated a goal-driven approach for analyzing and improving business processes. During the improvement phase of this approach, 28 process improvement principles were considered. The questionnaire evaluating users' perceptions indicates that users were satisfied with the approach and are willing to use it in future projects. However, the different phases of the approach were not separately evaluated. Consequently, it is hard to draw conclusions regarding users' perceptions of the technique supporting the improvement phase. In another study (Yilmaz et al. 2011), professional engineers working on a new outdoor product line were observed while applying the design heuristics as outlined by Daly et al. (2012). Yilmaz et al. (2011) found that these engineers consider design heuristics to be an effective mean to generating product innovation ideas. Given these positive findings and our expectation that users will experience the stimulating effects of the technique as mentioned in the previous subsection, we expect that users of the RePro technique are more satisfied with their technique than individual brainstormers. Also, they are expected to have a positive intention to use the technique.

Hypothesis 5: *Individuals using the RePro technique are* ***more satisfied*** *with their technique than individuals using traditional brainstorming.*

Hypothesis 6*: Individuals using the RePro technique have a* ***positive intention to use*** *the technique.*

6.3 Research methodology

In this section, we outline the set-up of the two controlled experiments. As recommended by Cooper and Schindler (2003), we describe the participants, experiment task, factor and factor levels, experiment procedure, response variables, as well as the pre-test and pilot. As mentioned earlier, the set-up of both experiments is highly similar, but the participants were graduate students in Industrial Engineering and Nursing & Midwifery respectively. We start with discussing the set-up of the first experiment. Subsequently, we outline the differences between the set-up of the first and the second experiment.

6.3.1 Set-up experiment 1

Participants

The participants of the first experiment were 89 graduate students in Industrial Engineering at Ghent University. Due to their solid educational background in process management, we contend that these students are likely to be quite representative of novice process consultants / analysts involved in rethinking care processes.

Demographic information regarding the participants can be found in Section 6.4.

To avoid problems with understanding process models that had to be studied as part of the experiment task, all participants were trained into the EPC process modeling notation prior to this experiment. This took place in the form of a university lecture of one hour.

All students received course credit for participation in the experiment. Additionally, the three best performing students received a cash prize of €75, €50, and €25 respectively.

Experiment task

We asked participants to generate improvement ideas for the cataract surgery process at the EyeClinic of Maastricht University Medical Center. A cataract leads to a decrease in vision due to a clouding of the lens inside the eye. It is conventionally treated with surgery. The cataract surgery process describes all diagnosis, treatment, and administrative steps from intake until discharge for cataract patients. As a basis for idea generation, all participants received a case description of this process. Based on a long-term collaboration with the EyeClinic, we were able to create a realistic case description together with its employees. The case description included information about (1) redesign objectives (i.e. reducing costs and throughput times, and increasing patient satisfaction), (2) redesign limitations / medical guidelines (e.g. surgery supervision of assistants is required), (3) process models including projections of actual routing fractions, wait- and process times, and cost information, (4) textual process descriptions, and (5) main problem areas as identified by employees and patients (e.g. scheduling assistants work overtime). As such, the case description covered the typical information that is collected as input for generating process improvement ideas (see Table 3.2 in Chapter 3).

Prior to the experiment, we conducted a pre-test and pilot study to check the understandability of the case description as well as the time needed to read the description (see last part of this section for more details).

Factor and factor levels

The factor considered in this study is the technique used to generate process improvement ideas. Two factor levels are distinguished, resulting in two experiment conditions: *traditional brainstorming (TB)* and *RePro*. Participants were randomly assigned to one of the two conditions, leading to groups of 44 and 45 individuals per condition respectively (see Figure 6.1).

	TB	RePro
Experiment Gent	44 individuals	45 individuals

Figure 6.1. Experiment conditions Gent.

Individuals in the TB condition received an instruction document that included the four brainstorming rules (Osborn 1953) formulated in process redesign terminology. Individuals in the RePro condition received an instruction document that - in addition to these rules - included the list of 46 RePro principles. As illustrated in Figure 6.2, each RePro principle contained a title, a definition, an explanation, as well as an application example.

1. Control relocation: ***'Move controls towards the customers (patients)'***

By moving checks and other operations that are part of a process to the customer, costs can be reduced and customer satisfaction might increase. A disadvantage of this solution is a higher probability of fraud.

Example: Ask the patient, instead of the nurse, to pick up the drugs by the hospital pharmacy.

Figure 6.2. Example of RePro principle in technique description.

To prevent a positive instrument bias, two reviewers independently checked that all application examples of the RePro principles were unrelated to the cataract surgery process.

Experiment procedure

The experiment started with a plenary video message of the medical manager of the Eyeclinic. In this video message, the objective of the experiment task and the cataract surgery process were briefly discussed. After this video message, all participants received a hand-out, which included a reading guide, a description of the experiment task, the case description mentioned earlier, and a technique description (TB or RePro). The first two steps in the experiment task description instructed participants in both conditions to read the case description and technique description successively. As part of the RePro technique description, participants had to read a summary of the RePro technique and screen all RePro principles.

After the first two preparatory steps, participants in both conditions were asked to generate as many good process improvement ideas as possible while using the assigned technique. For each idea, all participants had to document the concrete process change as well as its expected effect. Additionally, participants in the RePro condition were asked to indicate which RePro principle inspired them to come up with the suggested improvement. For the complete experiment task, i.e. reading the hand-out, which included the case description and the technique description, and generating process improvement ideas, all participants had 2 hrs 40 m available. Although this duration can be considered somewhat long, the pilot study revealed that students showed enthusiasm for the experiment task and were motivated to keep on generating ideas until the end of the session.

Immediately after finishing the experiment task, participants received a digital, post-experiment questionnaire. Participants had to indicate personal characteristics (e.g. age, sex, and prior experience with cataract surgery processes), whether or not they used the assigned technique, and their satisfaction with the technique. Participants in the RePro condition were additionally asked about their intention to use the technique. Participants in the TB condition were not asked a similar question, due to the fact that they lacked detailed information with regard to a relevant benchmark, i.e. the RePro technique. After completing the questionnaire, all participants were debriefed and thanked. Furthermore, the price winners were announced during a guest-lecture.

Response variables

Productivity was determined by counting the number of unique ideas generated by each individual. Two raters, who where blind to experiment conditions, independently evaluated the entered input of each individual. They were instructed to identify redundant ideas, ideas not describing an improvement action (e.g. the phrase “waiting time before consultation is long” does not describe an improvement action), and ideas containing multiple unrelated ideas. Redundant ideas and ideas not describing an improvement action were eliminated for calculation purposes. Ideas containing multiple unrelated ideas were split for these purposes. For each of the three correction types, inter-rater-agreement was measured by the Cohen’s kappa statistic (Sim and Wright 2005). Disagreements between the reviewers were resolved by consensus.

Diversity was analyzed on two different levels of granularity: (1) *Category_diversity* defined as the number of different RePro categories addressed by a participant and (2) *Principle_diversity* defined as the number of different RePro principles covered by a participant. In order to calculate these measures, two trained and independent raters categorized all ideas generated by individuals in the TB and the RePro condition. In particular, all ideas were categorized in the nine RePro categories and the 46 RePro principles. Note that experiment participants in the RePro condition recorded the principles which inspired them to come up with a certain process improvement idea. However, we decided to not make use of these recordings for categorization purposes, because participants, as expected, did not always record the same principle for a similar process improvement idea. For example, some participants recorded the “task automation” principle (*Information and communication technology* category) for the idea to automate the manual data transfer between the medical instruments and the hospital information system, whereas other participants recorded the “task elimination” principle (*Tasks* category) for this idea. In order to make the diversity measures less vulnerable to subjectivity, two trained and independent raters coded all ideas. In case an idea could not been assigned to one of the existing RePro categories and / or principles by the raters, the idea was assigned to a newly identified category and / or principle. The two raters were blind to experiment conditions. This implies that raters were also blind to the principles that were recorded by the experiment participants in the RePro condition. Analogously to the productivity measure, Cohen’s kappa was used to measure inter-rater-agreement and disagreements between raters were resolved by consensus.

Quality was determined by counting the number of high-quality ideas. Reinig et al. (2007) argue that this measure for quality is a better measure than the *average* quality. A major disadvantage of the average measure is that it decreases in value as more low-quality ideas are generated, even if a large number of high-quality ideas are present in the set. For example, the average quality is higher for individuals generating two ideas with quality scores {5, 5} than individuals generating five ideas with quality scores {5, 5, 5, 5, 4}. Hence, we decided to focus on the number of high-quality ideas as the measure of quality in this study. In order to calculate this number, all ideas were evaluated with regard to effectiveness and feasibility in line with (Rietzschel et al. 2010). Effectiveness was rated on a five-point Likert scale, ranging from (1) "highly ineffective" to (5) "highly effective". Similarly, feasibility was evaluated on a five-point Likert scale, ranging from (1) "not at all feasible" to (5) "highly feasible". In line with recommendations from Reinig et al. (2007), we defined high-quality ideas as ideas with effectiveness and feasibility scores higher than 3 in this study. Two expert raters with detailed knowledge about the cataract surgery process at Maastricht University Medical Center were involved in evaluating the effectiveness and feasibility of the ideas. One rater evaluated all ideas and a second rater evaluated a 10% random sample of the ideas. Inter-rater-agreement was determined by calculating the intra-class coefficient, using a two-way random model and absolute agreement definition (McGraw and Wong 1996). The two-way random model is commonly used when a *fixed number* of raters evaluate the *same set* of observations / ideas. We used the absolute agreement definition, because we are also interested in systematic differences between levels of ratings. Disagreements between the raters with regard to the effectiveness and feasibility scores were resolved by consensus.

Originality was determined by counting the number of original ideas of each individual. Analogously to prior studies (Diehl and Stroebe 1987; Rietzschel et al. 2007; Rietzschel et al. 2010), all ideas were rated on a five-point Likert scale ranging from (1) "not at all original" to (5) "highly original". Similar to the quality metric in the previous paragraph, we determined the number of original ideas by counting the number of ideas with an originality score higher than 3. Two independent raters coded all ideas on the five-point Likert scale. Inter-rater-agreement was again evaluated by means of calculating the intra-class coefficient, using a two-way random model and absolute agreement definition. Disagreements between the raters were resolved by consensus.

Satisfaction with the provided technique was measured using a single questionnaire item in line with (Rietzschel et al. 2006): "How satisfied are you with the provided traditional brainstorming / RePro technique?" Responses were given on a seven-point Likert scale ranging from "completely dissatisfied" (1) to "completely satisfied" (7).

Intention to use the RePro technique was measured using the two items of the Method Evaluation Model (Moody 2003), which is based on the Technology Acceptance Model. More specifically, we used the following items: (1) "I would definitely not use the RePro technique for similar process improvement initiatives" (reverse scored); (2) "I intend to use the RePro technique in preference to relying on just personal experience and intuition if I have to generate improvement ideas in future similar process improvement initiatives". Responses to both items were given on seven-point Likert scale ranging from "completely disagree" (1) to "completely agree" (7). The internal consistency of the two-item construct intention-to-use was measured using Cronbach's alpha (Bland and Altman 1997).

Pre-test and pilot experiment

Prior to the first experiment, a pre-test and pilot experiment were conducted. The pre-test was used to check the understandability of the hand-out material and to evaluate the timing of the session. During the pre-test, participants went through the complete experiment procedure as outlined earlier. However, at this stage, the post-experiment questionnaire was not used to measure the constructs as specified above (e.g. satisfaction with the provided technique), but to evaluate and improve the hand-out material. 12 students in Industrial Engineering with at least three-year educational experience at Eindhoven University of Technology (TU/e) participated in the pre-test. They were randomly assigned to the two experiment conditions. The pre-test led to a more brief description of the post-operative phase of the cataract surgery process, small improvements regarding the readability of process models, and minor textual updates of the hand-out material.

After the pre-test, a pilot experiment was conducted to check the understandability of the updated hand-out material, post-experiment questionnaire, and the timing of the complete experiment procedure. 13 third-year undergraduate students in Industrial Engineering at TU/e were randomly assigned to the two conditions. The pilot study revealed that participants were motivated to use all time available to generate improvement ideas and were enthusiastic about the “real-life” experiment task. In addition, minor final textual corrections regarding the hand-out material were suggested.

6.3.2 Set-up experiment 2

To gain insights into the external validity of the results of the first experiment, we conducted a second experiment with different experiment participants, i.e. graduate students in Nursing & Midwifery. The set-up of the experiment was identical to the first experiment, apart from the experiment participants and several small changes of the experiment procedure due to practical affairs. Below, we outline the differences between the first and second experiment.

Participants

The participants of the second experiment were 72 graduate students in Nursing & Midwifery at KU Leuven. These students are likely to be quite representative of novice healthcare professionals involved in rethinking care processes.

Demographic information with regard to the participants can be found in Section 6.4.

Analogously to the first experiment, all participants were trained into the EPC process modeling notation prior to this experiment during a university lecture of one hour. Moreover, all students received again course credit for participation and the three best performing students received a cash prize of €75, €50, and €25 respectively.

Furthermore, participants were again randomly assigned to one of the two conditions (TB and RePro), leading to groups of 35 and 37 individuals per condition respectively[7].

[7] Participants were randomly assigned to the conditions prior to the experiment. One participant entered a different condition that was originally assigned (RePro instead of TB).

Experiment procedure

Due to practical affairs, it was not possible to run a 2 hrs and 40 min experiment in accordance with the first experiment. We were only able to run a 1hrs and 45 min experiment. Consequently, we decided to complement the experiment with a homework assignment of approximately 45 min.

As part of the homework assignment, we asked students to read the case description and allowed them to mark inefficiencies as identifiable in this description. With regard to the experiment task, we only informed them that they would receive a concrete task description on the day of the experiment. Furthermore, we stressed the importance of reading the case description in order to be able to successfully complete the experiment. Finally, the students were instructed to read the case description not more than two days before the experiment and to bring the case description with them to the experiment.

On the day of the experiment, the experiment procedure was similar to the procedure of the first experiment. However, due to the homework assignment, participants no longer had to do a full reading of the case description before generating process improvement ideas.

6.4 Results

This section outlines the results of the experiments. Before presenting descriptive statistics and test results regarding our hypotheses, we discuss demographic information as well as data validation measurements and criteria for each of the experiments.

Demographic information

The average age of participants in the first experiment was 22.63 years (std: 0.93 years). About 38% of these participants were female. None of the participants indicated to have prior experience with or knowledge about cataract surgery processes. In the second experiment, the average age of the participants was 22.96 years (std: 2.56) and about 88% of them were female. Four participants in this experiment indicated to have prior experience with or knowledge about cataract surgery processes. We checked whether these four participants led to extreme values[8] regarding the response variables and whether they changed our findings due to affecting hypotheses test conclusions. It turned out that none of the four participants caused extreme values on any of the response variables. Moreover, hypotheses test conclusions are not affected with one exception, as indicated in Section 6.4.1. Consequently, all reported results below are based on analyses that include the scores of the four participants mentioned.

[8] Value < Q1 - 3 IQ or Value > Q3 + 3IQ; where Q1 = lower quartile, Q3 = upper quartile, and IQ = Q3 - Q1 = InterQuartile-range.

Data validation measurements and criteria

Response variables

As discussed in the research methodology section of this chapter, we evaluated inter-rater-reliability with regard to the ratings / assignments for different response variables (i.e. productivity, diversity, quality, and originality). Moreover, we investigated the internal consistency of the two-item intention-to-use construct. For both experiments, all these measurements and related interpretations are discussed in detail in Appendix E.1. In summary, all inter-rater-reliability scores indicate substantial to almost perfect agreement. Also, the scale of the intention-to-use construct has substantial to good internal consistency.

Enter criteria

We also checked in both experiments whether all participants had used the assigned technique. In the first experiment, seven participants in the TB condition and one participant in the RePro condition indicated in the questionnaire that they had not used the assigned technique. These eight participants were excluded from further analysis. Consequently, in the first experiment, 37 and 44 participants are part of the TB and the RePro condition respectively. In the second experiment, four participants in the TB condition indicated that they had not used the assigned technique and were excluded from further examination. As a result, the TB and the RePro condition contain 31 and 37 participants respectively.

6.4.1 Results hypotheses testing

This section presents descriptive statistics and test results regarding our hypotheses. We start with providing a brief overview of the hypothesis test results for both experiments. Subsequently, we discuss descriptive statistics and hypothesis test results in more detail for each response variable. A definition of each response variable can be found in the methodology section.

Overview hypothesis test results

The main results with regard to hypotheses testing are summarized in Table 6.1.

	Experiment 1	*Experiment 2*
Hypothesis 1 (productivity)	☺	☹
Hypothesis 2 (category-diversity)	☹	☹[a]
Hypothesis 2 (principle-diversity)	☺	☺
Hypothesis 3 (quality)	☺	☺
Hypothesis 4 (originality)	☺	☹[b]
Hypothesis 5 (satisfaction with the technique)	☺	☺
Hypothesis 6 (intention-to-use the technique)	☺	☺

Table 6.1. Summary test results with regard to hypotheses. ☺ = support for hypothesis; ☹ = no support for hypothesis. [a]We did not find support for this hypothesis after excluding four participants having experience with or knowledge about cataract surgery processes. [b]Although we did not find direct support for support our hypothesis regarding originality, we found that individuals using the RePro technique generated more ideas that were original *and high-quality* than individual brainstormers.

As shown in Table 6.1, we found support in both experiments for several of our hypotheses. In both experiments, individuals using the RePro technique generated *more diverse* ideas as compared to individual brainstormers, when measuring idea diversity on a fine-grained level. We also consistently found that individuals using the RePro technique generated *more high-quality* ideas than individuals using traditional brainstorming. Furthermore, users of the RePro technique were consistently *more satisfied* with their technique than individual brainstormers and *intend to use* the technique in future projects. Contrary to our expectations, the impact of the RePro technique on *productivity* in the experiments was either *small* or *not significant*. Moreover, we found *mixed results* with regard to the *number of original* ideas generated.

Descriptive statistics and hypothesis test results per response variable

In the remainder of this section, we present the results for each response variable in more detail. We present descriptive statistics and further explain the test results regarding our hypotheses. For both experiments, we report the means (M), standard deviations (std), medians (m), minimums (min) and maximums (max) in Tables 6.2 - 6.7. In text, only mean (M) values are reported.

In order to test for significant differences between the two conditions (i.e. *TB* and RePro), a choice had to be made with regard to using a parametric or non-parametric test for each response variable. Specifically, we had to make a choice between the parametric *independent-t test with or without Welch's correction* and the non-parametric *Mann-Whitney U-test*. In general, the independent t-test is preferred over the Mann-Whitney U-test, as the independent t-test has more statistical power (Nachar 2008). However, the independent t-test requires that the response variable under study is approximately normally distributed for both conditions (Green and Salkind 2003). In case this assumption was not met as determined by Shapiro's Wilk test ($p < 0.05$), the Mann-Whitney U-test was used for statistical testing. In case the normality assumption was not violated, we still had to make a choice between the independent t-test *with* or *without* Welch's correction (Green and Salkind 2003). The independent t-test *without* Welch's correction assumes that the variance is equal in both conditions. In order to check this homogeneity of variances assumption, Levene's test was used (Green and Salkind 2003). In case the homogeneity of variances assumption was violated ($p < 0.05$), the Welch t-test was used for hypothesis testing.

All test results related to the assumptions mentioned in the previous paragraph are outlined in Appendix E.2. Below, we only report the final hypothesis test results for each response variable. In addition to statistical significant values, we report effect sizes as these give insight into the size of the observed effects independent of possibly misleading influences of sample size (Fritz et al. 2012). With regard to parametric tests and non-parametric, we report Cohen's d (Fritz et al. 2012) and r proposed by Cohen (1988) respectively.

Productivity (H1)

Experiment	*Condition*	*Support*	*Descriptive statistics*		
			M (std)	*M*	*Min - Max*
Experiment 1	TB RePro	☺ (p = 0.042; r = 0.19)	14.59 (4.66) 17.84 (7.40)	14 17	7 - 24 8 - 37
Experiment 2	TB RePro	☹ (p = 0.127)	18.55 (5.15) 17.03 (5.62)	18 17	9 - 28 5 - 34

Table 6.2. Descriptive statistics of productivity ($N_{1.TB}$ = 37; $N_{1.RePro}$ = 44; $N_{2.TB}$ = 31; $N_{2.RePro}$ = 37). ☺ = support for hypothesis; ☹ = no support for hypothesis.

Experiment 1

A Mann-Whitney U-test reveals that productivity scores in the RePro condition (M = 17.84) are significantly higher than in the TB condition (M = 14.59) in experiment 1 when using a one-sided confidence interval of 95% (U = 996.00; z = 1.730; p = 0.042). The effect size (r = 0.19) indicates a small effect. As such, the results of experiment 1 provide **support** for **hypothesis 1**.

Experiment 2

A one-sided independent t-test assuming equal variances does not reveal significant differences between the productivity scores in the RePro condition (M = 17.03) and the TB condition (M = 18.55) in experiment 2 (t(66) = -1,154; p = 0.127). This implies that, contrary to experiment 1, the results in experiment 2 do **not** offer **support** for **hypothesis 1**.

Diversity (H2)

Experiment	*Condition*	*Support*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Category-diversity					
Experiment 1	TB RePro	☹ (p = 0.177)	6.41 (1.09) 6.70 (1.30)	6 7	4 - 8 4 - 9
Experiment 2	TB RePro	☹ (p = 0.057)*	6.26 (0.96) 6.81 (1.08)	6 7	4 - 8 5 - 9
Principle-diversity					
Experiment 1	TB RePro	☺ (p < 0.001; r = 0.42)	9.16 (2.47) 12.36 (4.28)	9 11.5	6 - 15 5 - 25
Experiment 2	TB RePro	☺ (p = 0.008; d = 0.57)	10.90 (2.13) 12.84 (4.14)	10 13	7 - 15 5 - 26

Table 6.3. Descriptive statistics of diversity ($N_{1.TB}$ = 37; $N_{1.RePro}$ = 44; $N_{2.TB}$ = 31; $N_{2.RePro}$ = 37). ☺ = support for hypothesis; ☹ = no support for hypothesis. *We did not find support for this hypothesis after excluding four participants having experience with or knowledge about cataract surgery processes.

Experiment 1

We ran a one-sided Mann-Whitney U-test to test for differences regarding the numbers of RePro categories (*category-diversity*) as well as the numbers of RePro principles covered by individuals (*principle-diversity)* in experiment 1. We did not find significant differences between the RePro condition (M = 6.70) and TB condition (M = 6.41) for category-diversity (U = 909.00; z = 0.927; p = 0.177).

However, for principle-diversity, results show that individuals in the RePro condition (M = 12.36) covered a significant higher number of principles than individuals in the TB condition (M = 9.16) (U = 1211.50; z = 3.790; p < 0.001). The effect size for principle-diversity (r =

0.42) shows a moderate effect. The fact that we only found a significant effect for principle-diversity, leads us to conclude that the results of experiment 1 provide only **partial support** for **hypothesis 2**.

Experiment 2

A one-sided Mann-Whitney U-test reveals that, contrary to experiment 1, individuals in the RePro condition (M = 6.81) covered more categories than individuals in the TB condition (M = 6.26) in experiment 2 (U = 724.00; z = 1.945; p = 0.026). The effect size (r = 0.24) indicates a small effect. When leaving out the participants with prior experience or knowledge about cataract surgery processes, the identified difference between conditions is no longer significant (p = 0.057).

A one-sided independent t-test while not assuming equal variances indicates that, analogously to experiment 1, individuals in the RePro condition (M = 12.84) covered a significant higher number of principles than individuals in the TB condition (M = 10.90) in experiment 2 (t(55,74) = 2.477; p = 0.008). The effect size (Cohen's d = 0.57) indicates a moderate effect. As such, the results with regard to category-diversity and principle-diversity in experiment 2 offer again **partial support** for **hypothesis 2**.

Quality (H3)

Experiment	*Condition*	*Support*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Experiment 1	TB	☺ (p = 0.002; r = 0.33)	5.22 (2.57)	5	1 - 11
	RePro		8.07 (4.85)	6	2 - 23
Experiment 2	TB	☺ (p = 0.020; r = 0.25)	6.29 (2.82)	6	2 - 14
	RePro		8.24 (3.70)	8	2 - 17

Table 6.4. Descriptive statistics of quality ($N_{1.TB}$ = 37; $N_{1.RePro}$ = 44; $N_{2.TB}$ = 31; $N_{2.RePro}$ = 37). ☺ = support for hypothesis; ☹ = no support for hypothesis.

Experiment 1

A one-sided Mann-Whitney U test reveals that individuals in the RePro condition (M = 8.07) generated a significant higher number of high-quality ideas than individuals in the TB condition (M = 5.22) in experiment 1 (U = 1122.00; z = 2.949; p = 0.002). The effect size (r = 0.33) shows a moderate effect[9]. This leads us to conclude that the results of experiment 1 provide **support** for **hypothesis 3**.

Experiment 2

Analogously to experiment 1, a one-sided Mann-Whitney U-test shows that individuals in the RePro condition (M = 8.24) generated a significant higher number of high-quality ideas than individuals in the TB condition (M = 6.29) in experiment 2 (U = 739.00; z = 2.052; p = 0.020).

[9] Note that an independent t-test assuming equal variances also indicates that the *average effectiveness* of the ideas generated by individuals in the RePro condition (M = 3.40) is significantly higher than in the TB condition (M = 3.25) (p = 0.006). The effect size (Cohen's d = 0.62) indicates a moderate effect.

The effect size (r = 0.25) indicates a small effect[10,11]. This implies that the results of experiment 2 also offer **support** for **hypothesis 3**.

Originality (H4)

Experiment	*Condition*	*Support*	*Descriptive statistics* *M (std)*	*m*	*Min - Max*
Number of original ideas					
Experiment 1	TB	☺ (p = 0.037; r = 0.20)	3.97 (3.16)	3	0 - 15
	RePro		5.45 (4.00)	5.5	0 - 16
Experiment 2	TB	☹ (p = 0.058)	5.19 (2.77)	6	1 - 11
	RePro		6.70 (3.75)	6	1 - 21
Number of original, high-quality ideas					
Experiment 1	TB	(p = 0.003; r = 0.31)	1.16 (1.54)	1	0 - 7
	RePro		2.57 (2.54)	2	0 - 10
Experiment 2	TB	(p = 0.004; r = 0.32)	1.58 (1.34)	1	0 - 5
	RePro		3.05 (2.63)	2	0 - 13

Table 6.5. Descriptive statistics of originality ($N_{1.TB}$ = 37; $N_{1.RePro}$ = 44; $N_{2.TB}$ = 31; $N_{2.RePro}$ = 37). ☺ = support for hypothesis; ☹ = no support for hypothesis.

Experiment 1

A one-sided Mann-Whitney U-test result shows that individuals in the RePro condition generated a significant higher number of original ideas (M = 5.45) than individuals in the TB condition (M = 3.97) in experiment 1 (U = 1001.00; z = 1.784; p = 0.037). The effect size (r = 0.20) indicates a small effect. As such, the results in experiment 1 offer **support** for **hypothesis 4**.

In order to investigate whether the originality effect also resulted in a higher number of original *and* high-quality ideas, we repeated the above analysis for the subset of high-quality ideas. A one-sided Mann-Whitney U-test reveals that individuals in the RePro condition (M = 2.57) also generated a significant higher number of original, high quality ideas than individuals in the TB condition (M = 1.16) (U = 110.00; z = 2.805; p = 0.003). The effect size (r = 0.31) shows a moderate effect.

Experiment 2

A one-sided Mann-Whitney U-test indicates that the difference between the number of original ideas generated by individuals in the RePro condition (M = 6.70) and individuals in the TB condition (M = 5.19) only approaches significance in experiment 2 (U = 700.50; z = 1.572; p = 0.058). Being strict, this leads us to conclude that the results in experiment 2 do **not** offer **support** for **hypothesis 4**[12].

Analogously to experiment 1, we repeated the analysis for the subset of high-quality ideas. A one-sided Mann-Whitney U-test shows that individuals in the RePro condition (M = 3.05) generated a significant higher number of original, high quality ideas than individuals in the

[10] In line with experiment 1, an independent t-test assuming equal variances, reveals that the *average effectiveness* of the ideas generated by individuals in the RePro condition (M = 3.43) is significantly higher than in the TB condition (M = 3.24) (p < 0.001). The effect size (Cohen's d = 0.93) indicates a strong effect.
[11] Contrary to experiment 1, an independent t-test assuming equal variances shows that the *average feasibility* of the ideas generated by individuals in the RePro condition (M = 4.27) is significantly lower than in the TB condition (M = 4.36) (p = 0.040). The effect size (Cohen's d = 0.51) indicates only a moderate effect.
[12] Note that an independent t-test assuming equal variances shows that the *average originality* of the ideas generated by individuals in the RePro condition (M = 2.87) is significantly higher than in the TB condition (M = 2.66) (p = 0.006). The effect size (Cohen's d = 0.57) reveals a moderate effect.

TB condition (M = 1.58) (U = 786.50; z = 2.673; p = 0.004). The effect size (r = 0.32) indicates a moderate effect. This implies that, although using the RePro does not lead to the generation of a significant higher number of original ideas, its usage leads to more original ideas that are of high quality as compared to traditional brainstorming.

Satisfaction with the technique (H5)

Experiment	*Condition*	*Support*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Experiment 1	TB	☺ (p = 0.007; r = 0.28)	4.70 (1.20)	5	2 - 7
	RePro		5.30 (1.41)	5.5	2 - 7
Experiment 2	TB	☺ (p = 0.017; r = 0.26)	5.06 (0.93)	5	3 - 7
	RePro		5.54 (1.01)	6	3 - 7

Table 6.6. Descriptive statistics of satisfaction with the technique ($N_{1.TB}$ = 37; $N_{1.RePro}$ = 44; $N_{2.TB}$ = 31; $N_{2.RePro}$ = 37). ☺ = support for hypothesis; ☹ = no support for hypothesis.

Experiment 1

A one-sided Mann-Whitney U-test reveals that individuals in the RePro condition (M = 5.30) are more satisfied with their technique than individuals in the TB condition (M = 4.70) in experiment 1 (U = 1067.50; z = 2.480; p = 0.007). The effect size (r = 0.28) shows a small effect. This implies that the results of experiment 1 offer **support** for **hypothesis 5**.

Experiment 2

Analogously to the experiment 1, a one-sided Mann-Whitney U-test reveals that individuals in the RePro condition (M = 5.54) are more satisfied with their technique than individuals in the TB condition (M = 5.06) in experiment 2 (U = 738.50; z = 2.183; p = 0.017). The effect size (r = 0.26) indicates a small effect. This leads us to conclude that also the results of experiment 2 provide **support** for **hypothesis 5**.

Intention-to-use the technique (H6)

Experiment	*Condition*	*Support*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Experiment 1	RePro	☺ (p < 0.001)	5.06 (1.21)	5.5	1 - 7
Experiment 2	RePro	☺ (p < 0.001)	4.87 (1.00)	5	2.5 - 6.5

Table 6.7. Descriptive statistics of intention-to-use the technique ($N_{1.RePro}$ = 44; $N_{2.RePro}$ = 37). ☺ = support for hypothesis; ☹ = no support for hypothesis.

Experiment 1

Table 6.7 shows that the mean intention-to-use (ITU) of the RePro technique is 5.06 (on a seven-point Likert scale) in experiment 1. 82% of the participants have a positive intention-to-use the RePro technique (ITU > 4). The percentages of participants with a neutral (ITU = 4) or negative (ITU < 4) intention-to-use the RePro technique are 5% and 14% respectively. The Wilcoxon Signed Rank test for non-normal distributions reveals that the median intention-to-use is significantly positive (z = 4.260; p < 0.001). As such, **support** is provided for **hypothesis 6** in experiment 1.

Experiment 2

As shown in Table 6.7, the mean intention-to-use of the RePro technique is 4.87 in experiment 2. The intention-to-use the RePro technique has been positively (ITU > 4) evaluated by 76% of the participants. The percentages of participants with a neutral (ITU = 4) or negative (ITU < 4) intention-to-use the RePro technique are 5% and 19% respectively. In line with the results of experiment 1, the Wilcoxon Signed Rank test indicates that the median intention-to-use is significantly positive (z = 4.084; p < 0.001). This implies that the results of experiment 2 also offer **support** for **hypothesis 6**.

6.4.2. Follow-up analysis

Contrary to our expectations, the number of unique ideas generated in the RePro condition in the first experiment strongly violated the normality assumption (p < 0.001 in Shapiro-Wilk's test) and hinted to a double-peaked distribution. This led us to investigate the idea generation logs in more detail and conduct follow-up discussions with eight participants in this condition[13].

By screening the idea generation logs and discussing our findings with participants, we identified two different styles of using the RePro technique. Several participants took the RePro principles as a starting point and went through them category-by-category to identify application opportunities. We will refer to this style as *opportunity-centric (OC)* generation (see Figure 6.3). Other participants took the problem areas as identifiable in the case description as a starting point. For identified process weaknesses, they screened each time the list of RePro principles to identify relevant solutions. This implies that the order of the RePro principles being applied did not follow the strict category-by-category application scheme. We will refer to this style as *problem-centric (PC)* generation (see Figure 6.3).

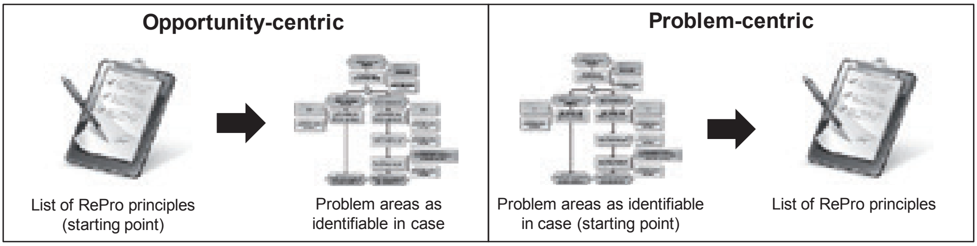


Figure 6.3. Usage styles RePro technique.

To gain insights into the effects of the usage style on the different response variables, we had to classify participants as adopters of either an *opportunity-centric* or *problem-centric* style. To objectify this classification, we decided to calculate the Adjusted Ratio of Clustering

[13] We used stratified sampling to gain the best insights into RePro usage styles: 4 individuals with a negative and 4 individuals with a positive intention-to use were randomly selected.

(ARC)[14] for each participant in the RePro condition. This ratio measures the degree to which consecutive ideas fall in the same RePro category corrected for chance (Roenker et al. 1971; Stroebe et al. 2010). Note that participants in the RePro condition were asked to record the principle that inspired them to come up with a certain idea. Based on these recordings, we were able to assign all consecutive ideas to the RePro categories and to calculate the ARC statistic. By determining the ARC, we received an indication for the degree of following an *opportunity-centric* category-by-category scheme (high ARC) versus a *problem-centric* approach (low ARC). In order to identify a cut-off ARC value for further statistical testing, we analyzed in both experiments the ARC - productivity scatterplot in line with (Williams et al. 2006). In both experiments, we identified an increase of the graph around ARC = 0.75. Hence, we decided to use ARC = 0.75 as cut-off value for classifying participants as being adopters of an OC (ARC >= 0.75) or PC generation (ARC < 0.75) style.

Due to the fact that we identified the two different styles already in the first experiment, we asked users of the RePro technique in the second experiment to indicate their usage style in the post-experiment questionnaire. A comparison of the outcomes revealed that the indicated usage style matched for 81% of the participants with the style as derived from the ARC value. In terms of Cohen's kappa, we concluded that agreement is substantial as well: 0.61. These results confirm that our post-hoc classification was based on a relevant factor and appropriate cut-off value.

In the remainder of this section, we discuss the results of the follow-up analysis in which we distinguish three groups of participants instead of two conditions: individuals using traditional brainstorming (TB), individuals adopting a *problem-centric* usage style of the RePro technique (RePro_PC), and individuals adopting an *opportunity-centric* usage style of the RePro technique (RePro_OC). In the first experiment, we count 37 participants in the TB group, 31 in the RePro_PC group, and 13 in the RePro_OC group. In the second experiment, 31 participants are part of the TB group, 17 of the RePro_PC group, and 20 of the RePro_OC group. Note that the RePro_PC and the RePro_OC group in both experiments are non-randomized groups that are based on a post-hoc classification. As a consequence, identified effects in our follow-up analysis are not free of a possible selection bias. This implies that identified effects might also be attributable to differences between groups with regard to characteristics of its members (e.g. degree of task motivation).

With regard to the second experiment, we also wish to note that the reported results below include the scores of the seven participants with an ambiguous usage style, i.e. participants whose indicated usage style in the questionnaire does not match with the style as derived from the ARC value. Furthermore, the reported results (for the second experiment) include the scores of the four participants having experience with or knowledge about cataract surgery processes. Nevertheless, we checked for these subgroups of participants whether they led to any extreme values in the three groups. Moreover, we ran all tests with and without these subgroups of participants. In this way, we gained insights into the robustness

[14] ARC = (R - E(R)) / (maxR - E(R)), where R is the number of observed RePro category repetitions (the next idea is from the same solution category), E(R) is the expected number of RePro category repetitions according to chance, and maxR is the maximum number of RePro category repetitions. maxR = N - k, where N is the total number of ideas generated and k is the number of RePro categories surveyed by a participant. For ARC calculation purposes, redundant ideas as well as ideas not describing an improvement action were included, because these contain information with regard to the order in which RePro principles are considered. All ideas, including ideas containing multiple ideas, were labeled with the RePro principle as indicated by the participant. Based on this label, the related RePro category was determined and ARC calculations were performed.

of our results. It turned out that none of these participants caused any extreme values. However, for a limited number of response variables, follow-up analysis results are affected. These are explicitly indicated.

Before showing the detailed results of the follow-up analysis for each response variable, we start with providing a brief overview of the follow-up analysis results for both experiments.

Overview follow-up analysis results

All results with regard to the follow-up analysis are summarized in Table 6.8. Note that in this table only groups in the same experiment are compared with each other.

	Experiment 1			*Experiment 2*		
	RePro OC	RePro PC	TB	RePro OC	RePro PC	TB
Productivity	☺	☹	☹	☺[a]	☹[a]	☺[a]
Category-diversity	☺	☹	☹	☺	😐	☹
Principle-diversity	☺	☹	☹	☺	☹	☹
Quality	☺	☹	☹	☺	☹	☹
Originality	☺	☹	☹	☺	☹	☹
Satisfaction with the technique	😐	😐	😐	😐	😐	😐
Intention-to-use the technique	😐	😐		😐	😐	

Table 6.8. Summary test results with regard to follow-up analysis. Smileys with the same color indicate that there are *no* significant differences between the scores in the respective groups with regard to a certain outcome measure. The scores in groups with a green smiley (☺) are significantly higher than the scores in groups with a red smiley (☹). The scores in groups with an orange smiley (😐) do *neither* significantly differ from the scores in the groups with a green smiley (☺), *nor* from the scores in the groups with a red smiley (☹).[a] The differences became only significant after excluding seven participants with an ambiguous usage style.

The follow-up analysis results show that scores on most response variables are affected by the way the RePro technique is used. Specifically, follow-up analysis results in both experiments reveal that *only* individuals in the RePro condition adopting an *opportunity-centric* style generated *more diverse*, *more high-quality*, and *more original ideas* than individuals using traditional brainstorming. Participants in the RePro condition who adopted a *problem-centric* style did not significantly score better than individual brainstormers on any of the response variables. They scored significantly worse than *opportunity-centric* adopters on all response variables except satisfaction with and intention-to-use the technique.

Follow-up analysis results per response variable

In the remainder of this section, the follow-up analysis results for each response variable are presented in more detail. Similar to Section 6.4.1, we present descriptive statistics in Tables 6.9 - 6.15 and further explain test results.

In order to test for significant differences between the three groups (i.e. *TB, RePro_PC* and *RePro_*OC), we had to make a choice between the parametric *One-way ANOVA with or without Welch's correction* and the non-parametric *Kruskal-Wallis test*. Contrary to the independent t-test and the Mann-Whitey U-test, both tests can be used to test for significant differences between *three or more* groups (Green and Salkind 2003). Similar to the procedure in Section 6.4.1, a choice for the parametric One-way ANOVA with or without Welch's correction or the non-parametric Kruskal-Wallis test depended on whether the normality assumption was violated or not. In case this assumption was not violated, we used a One-Way ANOVA for statistical testing. Whether the Welch ANOVA or regular One-Way ANOVA was selected was dependent on whether the homogeneity of variances assumption was violated or not.

In line with Section 6.4.1, we report all test results related to the assumptions in Appendix E.3. Below, we only provide the final follow-up test results for each response variable.

Productivity

Experiment	*Condition*	*Score indication*	*Descriptive statistics*		
			M (std)	*M*	*Min - Max*
Experiment 1	TB	☹	14.59 (4.66)	14	7 - 24
	RePro_PC	☹	14.90 (4.21)	15	8 - 24
	RePro_OC	☺	24.85 (8.74)	24	12 - 37
Experiment 2	TB	☺*	18.55 (5.15)	18	9 - 28
	RePro_PC	☹*	15.00 (5.28)	15	5 - 24
	RePro_OC	☺*	18.75 (5.45)	19	10 - 34

Table 6.9. Follow-up descriptive statistics of productivity ($N_{1.TB}$ = 37; $N_{1.RePro\_PC}$ = 31; $N_{1.RePro\_OC}$ = 13; $N_{2.TB}$ = 31; $N_{2.RePro\_PC}$ = 17; $N_{2.RePro\_OC}$ = 20). The definitions of the smileys are discussed in the caption of Table 6.8. p-values and effect sizes are only reported in text. * The differences became only significant after excluding seven participants with an ambiguous usage style.

Experiment 1

In experiment 1, correlation analysis between ARC and productivity reveals a positive and significant correlation (Spearman's rho = 0.377; p = 0.012), which indicates that the usage style of RePro is strongly connected to productivity. Whereas the normality assumption had to be rejected for productivity data in the RePro condition before the ARC classification, the productivity distributions of the two post-hoc groups no longer violate this assumption.

A Welch ANOVA indicates that the productivity scores are significantly different between groups, while using a two-sided conference interval of 95% (Welch's F(2, 28.855) = 8.110; p < 0.001). Games-Howell post-hoc tests reveal that the participants using a RePro_OC style (M = 24.85) generated significantly more ideas than participants in the TB (M = 14.59) and the RePro_PC (M = 14.90) group (p = 0.003 and p = 0.004 respectively). The effect sizes (Cohen's d = 1.72 and d = 1.69 respectively) indicate strong effects. Differences between adopters of a RePro_PC generation style and participants using TB are not significant (p = 0.956). In summary, the results in experiment 1 reveal that adopters of an ***opportunity-centric*** application scheme of RePro generated **more ideas** than ***problem-centric*** adopters of the RePro technique and individual **brainstormers**.

Experiment 2

Analogously experiment 1, there is a positive and significant correlation between ARC and productivity in experiment 2 (Spearman's rho = 0.395; p = 0.015).

Contrary to experiment 1, a One-way ANOVA indicates that there are no significant productivity differences between the TB (M = 18.55), the RePro_PC (M = 15.00), and the

RePro_OC (M = 18.75) group in the second experiment ($F(2, 66) = 3.029$; $p = 0.055$). However, we have to note that excluding participants with an ambiguous usage style of the RePro technique influences this finding. When excluding these seven participants, a one-way ANOVA indicates significant differences between groups ($F(2, 58) = 3.814$; $p = 0.028$). Tukey's post-hoc tests reveal that the differences between the RePro_PC group and the two other groups becomes significant (p = 0.034; d = 0.94 for RePro_OC - RePro_PC and p = 0.044; d = 0.86 for TB - RePro_PC)[15]. This result suggests that ***opportunity-centric*** adopters of the RePro technique and individual **brainstormers** generated **more ideas** than individuals using the RePro technique in a ***problem-centric*** manner in experiment 2.

Diversity

Experiment	*Condition*	*Score indication*	*Descriptive statistics*		
			M (std)	*M*	*Min - Max*
Category-diversity					
Experiment 1	TB	☹	6.41 (1.09)	6	4 - 8
	RePro_PC	☹	6.39 (1.20)	6	4 - 9
	RePro_OC	☺	7.46 (1.27)	8	5 - 9
Experiment 2	TB	☹	6.26 (0.96)	6	4 - 8
	RePro_PC	😐	6.53 (1.12)	6	5 - 9
	RePro_OC	☺	7.05 (1.00)	7	5 - 9
Principle-diversity					
Experiment 1	TB	☹	9.16 (2.47)	9	6 - 15
	RePro_PC	☹	10.61 (2.61)	10	5 - 17
	RePro_OC	☺	16.54 (4.67)	17	10 - 25
Experiment 2	TB	☹	10.90 (2.13)	10	7 - 15
	RePro_PC	☹	11.24 (3.70)	11	5 - 18
	RePro_OC	☺	14.20 (4.09)	14	7 - 26

Table 6.10. Follow-up descriptive statistics of diversity ($N_{1.TB} = 37$; $N_{1.RePro\_PC} = 31$; $N_{1.RePro\_OC} = 13$; $N_{2.TB} = 31$; $N_{2.RePro\_PC} = 17$; $N_{2.RePro\_OC} = 20$). The definitions of the smileys are discussed in the caption of Table 6.8.

Experiment 1

In experiment 1, correlation analyses between ARC and diversity reveal a positive and significant correlation between ARC and principle-diversity (Spearman's rho = 0.459; p = 0.002), whereas the correlation between ARC and category-diversity only approaches significance (Spearman's rho = 0.285; p = 0.061).

A Kruskal-Wallis test reveals significant differences between groups with regard to category-diversity ($H(2) = 7.366$; $p = 0.025$). Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. These post-hoc comparisons show a significant difference between the RePro_OC (M = 7.46) and the TB (M = 6.41) group (p = 0.039) and between the RePro_OC and the RePro_PC (M = 6.39) group (p = 0.032). The related effect sizes (r = 0.36 and r = 0.37 respectively) indicate moderate effects. No difference was found between the RePro_PC and the TB group (p = 1.000). In summary, this implies that in experiment 1 adopters of the ***opportunity-centric*** usage style of the RePro technique covered **more categories** than adopters of the ***problem-centric*** style and individual **brainstormers**.

[15] Additionally excluding participants having experience with or knowledge about cataract surgery processes does not change the identified significant differences between groups.

With regard to principle-diversity, a Kruskal-Wallis test reveals significant differences between groups as well ($H(2) = 26.100$; $p < 0.001$). Again, test results only show significant differences between the RePro_OC (M = 16.54) and the TB (M = 9.16) group ($p < 0.001$) and between the RePro_OC and the RePro_PC (M = 10.61) group ($p = 0.002$). The related effect sizes ($r = 0.65$ and $r = 0.60$ respectively) indicate strong effects. No difference was found between the RePro_PC and TB group ($p = 0.108$). Hence, similar to category-diversity, the results of experiment 1 lead us to conclude that adopters of the ***opportunity-centric*** usage style of the RePro technique covered **more principles** than adopters of the ***problem-centric*** style and individual **brainstormers**.

Experiment 2

In experiment 2, correlation analyses between ARC and diversity reveal two positive and signification correlations (Spearman's rho = 0.339; $p = 0.040$ for category-diversity and Spearmann's rho = 0.438; $p = 0.007$ for principle-diversity).

A Kruskal-Wallis test indicates significant differences between groups with regard to category-diversity ($H(2) = 6.330$; $p = 0.042$). The related post-hoc comparisons reveal a significant difference between the RePro_OC (M = 7.05) and the TB (M = 6.26) group ($p = 0.038$). The related effect size ($r = 0.35$) shows a moderate effect. No differences were found between any other combinations ($p = 0.331$ for RePro_OC - RePro_PC and $p = 1.000$ for RePro_PC - TB). In summary, this implies that only adopters of the ***opportunity-centric*** usage style of the RePro technique covered **more categories** than individual **brainstormers** in the second experiment[16].

With regard to principle-diversity, a one-way ANOVA shows significant differences between groups ($F(2, 65) = 6.949$; $p = 0.002$). Analogously to experiment 1, Tukey post-hoc comparisons reveal that the RePro_OC (M = 14.20) group outperforms the TB (M = 10.90) group ($p = 0.002$) as well as the RePro_PC (M = 11.24) group ($p = 0.019$) in terms of the number of principles covered. The related effect sizes (Cohen's $d = 1.08$ and $d = 0.76$ respectively) indicate strong and moderate effects respectively. No significant differences were identified between the RePro_PC and the TB group ($p = 0.938$). Hence, similar to experiment 1, the results of experiment 2 show that ***opportunity-centric*** adopters of the RePro technique covered **more principles** than ***problem-centric*** adopters and individuals using traditional **brainstorming**.

[16] Note that, in both experiments, we consistently found that the average number of ideas generated in the *external environment* category is significantly higher in the RePro_OC group than in TB group ($p < 0.001$ for pairwise comparisons in both experiments). These ideas are related to improving the collaboration and communication with external parties, such as preventing the duplicate execution of diagnostic tests by making use of test outcomes of general practitioners and external optometrists.

Quality

Experiment	*Condition*	*Score indication*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Experiment 1	TB	☹	5.22 (2.57)	5	1 - 11
	RePro_PC	☹	6.19 (2.77)	5	2 - 13
	RePro_OC	☺	12.54 (5.85)	12	4 - 23
Experiment 2	TB	☹	6.29 (2.82)	6	2 - 14
	RePro_PC	☹	6.82 (3.11)	6	2 - 15
	RePro_OC	☺	9.45 (3.80)	8.50	4 - 17

Table 6.11. Follow-up descriptive statistics of quality ($N_{1.TB}$ = 37; $N_{1.RePro\_PC}$ = 31; $N_{1.RePro\_OC}$ = 13; $N_{2.TB}$ = 31; $N_{2.RePro\_PC}$ = 17; $N_{2.RePro\_OC}$ = 20). The definitions of the smileys are discussed in the caption of Table 6.8.

Experiment 1

In experiment 1, correlation analysis between ARC and the number of high-quality ideas reveal a positive and significant correlation (Spearman's rho = 0.461; p = 0.002).

A Kruskal-Wallis reveals significant differences between groups (H(2) = 19.013; p < 0.001). The related post-hoc comparisons indicate a significant difference between the RePro_OC (M = 12.54) and the TB (M = 5.22) group (p < 0.001) and between the RePro_OC and the RePro_PC (M = 6.19) group (p = 0.004). The related effect sizes (r = 0.58 and r = 0.53 respectively) show strong effects[17]. No differences were found between the RePro_PC and the TB group (p = 0.473). In summary, these results indicate that adopters of the ***opportunity-centric*** usage style of the RePro technique generated **more high-quality ideas** than adopters of the ***problem-centric* style** and individual **brainstormers**.

Experiment 2

Also in experiment 2, there is a positive and significant correlation between ARC and the number of high-quality ideas (Spearman's rho = 0.330; p = 0.046).

A one-way ANOVA shows significant differences between groups (F(2, 65) = 6.216; p = 0.003). In line with the results of experiment 1, Tukey's post-hoc tests test results only reveal significant differences between the RePro_OC (M = 9.45) and the TB (M = 6.29) group (p = 0.003) and between the RePro_OC and the RePro_PC (M = 6.82) group (p = 0.041). The related effect sizes (Cohen's d = 0.98 and d = 0.75 respectively) indicate strong and moderate effects. No differences were found between the RePro_PC and the TB group (p = 0.846). So, similar to experiment 1, the results of experiment 2 lead us to conclude that ***opportunity-centric*** adopters of the RePro technique generated **more high-quality ideas**

[17] Note that a one-way ANOVA also shows significant differences between groups regarding the *average effectiveness* of ideas generated (F(2, 78) = 5.002; p = 0.009). The Tukey's post-hoc tests reveal that the RePro_OC (M = 3.47) group outperforms the TB (M = 3.25) group (p = 0.010). The related effect size (Cohen's d = 0.99) reveals a strong effect. The scores in the RePro_PC (M = 3.36) group do not significantly differ from the two other groups (p = 0.326 for RePro_OC - RePro_PC; p = 0.118 for RePro_PC - TB).

than ***problem-centric*** adopters and individual **brainstormers**[18].

Originality

Experiment	*Condition*	*Score indication*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Number of original ideas					
Experiment 1	TB	☹	3.97 (3.16)	3	0 - 15
	RePro_PC	☹	4.23 (3.19)	3	0 - 16
	RePro_OC	☺	8.38 (4.31)	9	0 - 14
Experiment 2	TB	☹	5.19 (2.77)	6	1 - 11
	RePro_PC	☹	5.29 (2.34)	5	1 - 9
	RePro_OC	☺	7.90 (4.33)	7.50	2 - 21
Number of original, high-quality ideas					
Experiment 1	TB	☹	1.16 (1.54)	1	0 - 7
	RePro_PC	☹	1.68 (1.81)	1	0 - 7
	RePro_OC	☺	4.69 (2.81)	4	0 - 10
Experiment 2	TB	☹	1.58 (1.34)	1	0 - 5
	RePro_PC	☹*	2.00 (1.62)	2	0 - 6
	RePro_OC	☺*	3.95 (3.02)	3.5	0 - 13

Table 6.12. Follow-up descriptive statistics of originality ($N_{1.TB}$ = 37; $N_{1.RePro\_PC}$ = 31; $N_{1.RePro\_OC}$ = 13; $N_{2.TB}$ = 31; $N_{2.RePro\_PC}$ = 17; $N_{2.RePro\_OC}$ = 20).). The definitions of the smileys are discussed in the caption of Table 6.8. * The differences became only significant after excluding seven participants with an ambiguous usage style and / or four participants having experience with or knowledge about cataract surgery processes.

Experiment 1

In experiment 1, there is a positive and significant correlation between ARC and the number of original ideas (Spearman's rho = 0.363; p = 0.015).

A Kruskal-Wallis test shows significant differences between groups (H(2) = 11.307; p = 0.004). The related post-hoc comparisons reveal a significant difference between the RePro_OC (M = 8.38) and the TB (M = 3.97) group (p = 0.003) and between the RePro_OC and the RePro_PC (M = 4.23) group (p = 0.013). The related effect sizes (r = 0.45 for both comparisons) indicate moderate effects. No differences were found between the RePro_OC and the TB group (p = 1.000). In summary, this implies that adopters of the ***opportunity-centric*** usage style of the RePro technique generated **more original ideas** than adopters of the ***problem-centric*** style and individual **brainstormers**.

Also in this follow-up analysis, we repeated the analysis for the subset of high-quality ideas. We identified a positive and significant correlation between ARC and the number of original, high-quality ideas (Spearman's rho = 0.453; p = 0.002).

A Kruskal-Wallis test reveals again significant differences between groups (H(2) = 19.213; p < 0.001). The related post-hoc comparisons reveal a significant difference between the

[18] In line with experiment 1, a one-way ANOVA shows significant differences between groups with regard to the *average effectiveness* of ideas generated (F(2, 65) = 7.368; p = 0.001). The Tukey's post-hoc tests reveal that the RePro_OC (M = 3.45) and the RePro_PC (M = 3.41) group outperform the TB (M = 3.24) group (p = 0.002 and p = 0.022 respectively). The related effect sizes (Cohen's d = 0.97 and d = 0.78) shows a strong and moderate effect respectively. The scores in the RePro_OC and RePro_PC group do not significantly differ from each other (p = 0.833). However, we have to note that these results are affected by leaving out participants with an ambiguous usage style and / or participants having experience with or knowledge about cataract surgery processes. When excluding these participants, the results indicate that only the RePro_OC group outperforms the TB group in terms of the average effectiveness of ideas generated.

RePro_OC (M = 4.69) and the TB (M = 1.16) group ($p < 0.001$) and between the RePro_OC and the RePro_PC (M = 1.68) group (p = 0.002). The related effect sizes (r = 0.59 and r = 0.53 respectively) indicate strong effects. No differences were found between the RePro_OC and the TB group (p = 0.668). As such, these results indicate that ***opportunity-centric*** adopters of the RePro technique also generated **more original, high-quality ideas** than ***problem-centric*** adopters and individual **brainstormers**.

Experiment 2

Analogously to experiment 1, there is a positive and significant correlation between ARC and the number of original ideas in experiment 2 (Spearman's rho = 0.453; p = 0.005).

A one-way ANOVA indicates significant differences between groups (F(2, 65) = 4.86; p = 0.011). In line with the results of experiment 1, Tukey's post-hoc tests reveal significant differences between the RePro_OC (M = 7.90) and the TB (M = 5.19) group (p = 0.013) and between the RePro_OC and the RePro_PC (M = 5.29) group (p = 0.044). The related effect sizes (Cohen's d = 0.78 and d = 0.73 respectively) indicate moderate effects. No differences were identified between the RePro_PC and the TB group (p = 0.944)[19]. Hence, similar to experiment 1, the results of experiment 2 lead us to conclude that ***opportunity-centric*** adopters of the RePro technique generated **more original ideas** than ***problem-centric*** adopters and individual **brainstormers**.

In the follow-up analysis, we also found a positive and significant correlation between ARC and the number of original, high-quality ideas (Spearman's rho = 0.440; p = 0.006).

A Kruskal-Wallis test indicates significant differences between groups (H(2) = 12.138; p = 0.002). Post-hoc tests show significant differences between the RePro_OC (M = 3.95) and the TB (M = 1.58) group ($p < 0.002$), but not between the other group combinations (p = 0.076 for RePro_OC - RePro_PC and p = 1.000 for RePro_PC - TB). The related effect size (r = 0.48) indicates a moderate effect. However we have to note that these results are slightly affected by leaving out participants with an ambiguous usage style and / or participants having experience with or knowledge about cataract surgery processes. When excluding these participants, the difference between the RePro_OC and the RePro_PC group becomes significant as well ($p < 0.044$). This last result suggests that, similar to experiment 1, ***opportunity-centric*** adopters of the RePro technique generated **more original, high-quality ideas** than ***problem-centric*** adopters and individual **brainstormers**.

[19] Note that a one-way ANOVA) also shows significant differences between groups with regard to the *average originality* of ideas generated (F(2, 65) = 3.235; p = 0.046). Tukey's post-hoc tests reveal that the RePro_OC (M = 2.91) group outperforms the TB (M = 2.66) group (p = 0.038). The related effect size (Cohen's d = 0.74) indicates a strong effect. The scores in the RePro_PC (M = 2.80) group do not significantly differ from the two other groups (p = 0.592 for RePro_OC - RePro_PC; p = 0.392 for RePro_PC - TB).

Satisfaction with the technique

Experiment	*Condition*	*Score indication*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Experiment 1	TB	😐	4.70 (1.20)	5	2 - 7
	RePro_PC	😐	5.23 (1.43)	5	2 - 7
	RePro_OC	😐	5.46 (1.39)	6	2 - 7
Experiment 2	TB	😐	5.06 (0.93)	5	3 - 7
	RePro_PC	😐	5.41 (1.18)	6	3 - 7
	RePro_OC	😐	5.65 (0.88)	6	4 - 7

Table 6.13. Follow-up descriptive statistics of satisfaction with the technique ($N_{1.TB}$ = 37; $N_{1.RePro\_PC}$ = 31; $N_{1.RePro\_OC}$ = 13; $N_{2.TB}$ = 31; $N_{2.RePro\_PC}$ = 17; $N_{2.RePro\_OC}$ = 20). The definitions of the smileys are discussed in the caption of Table 6.8.

Experiment 1

In experiment 1, there is no significant correlation between ARC and satisfaction with the RePro technique (Spearman's rho = 0.252; p = 0.094).

Nonetheless, a Kruskal-Wallis test was conducted to test for significant differences between groups. Pairwise comparisons of the three groups as part of the Kruskal-Wallis test (H(2) = 6.359; p = 0.041) do not reveal significant differences between the three groups (p = 0.115 for RePro_OC - TB, p = 0.114 for RePro_PC - TB, and p = 1.000 for RePro_PC - RePro_OC).

Experiment 2

In line with experiment 1, there is no significant correlation between ARC and satisfaction with the RePro technique in experiment 2 (Spearman's rho = -0.052; p = 0.761).

Moreover, a Kruskal-Wallis test does not indicate significant differences between groups (H(2) = 4.784; p = 0.091).

Intention-to-use the technique

Experiment	*Condition*	*Score indication*	*Descriptive statistics*		
			M (std)	*m*	*Min - Max*
Experiment 1	RePro_PC	😐	5.03 (1.17)	5	2.5 - 7
	RePro_OC	😐	5.11 (1.37)	5.5	1 - 6.5
Experiment 2	RePro_PC	😐	4.91 (1.12)	5	2.5 - 6.5
	RePro_OC	😐	4.85 (0.90)	5	3 - 6

Table 6.14. Follow-up descriptive statistics of intention-to-use the technique ($N_{1.RePro\_PC}$ = 31; $N_{1.RePro\_OC}$ = 13; $N_{2.RePro\_PC}$ = 17; $N_{2.RePro\_OC}$ = 20). The definitions of the smileys are discussed in the caption of Table 6.8. p-values and effect sizes are only reported in text.

Experiment 1

There is no significant correlation between ARC and intention-to-use the RePro technique in experiment 1 (Spearman's rho = 0.256; p = 0.094).

In line with this result, a Mann-Whitney U-test does not indicate a significant difference between the RePro_OC (M = 5.11) and the RePro_PC (M = 5.03) group (U = 227.50; z = 0.683; p = 0.495).

Experiment 2

Also in experiment 2, the correlation between ARC and intention-to-use the RePro technique turns out to be not significant (Spearman's rho = -0.145; p = 0.392).

An independent t-test assuming equal variances also does not reveal a significant difference between the RePro_OC (M = 4.85) and the RePro_PC (M = 4.91) group in experiment 2 (t(35) = 0.185; p = 0.854).

6.5 Discussion

By means of conducting two lab experiments, we investigated the impact of the RePro technique on workshop outcomes and compared its performance with traditional brainstorming. In particular, we evaluated the impact on productivity as well as on the diversity, quality, and originality of ideas generated. Moreover, effects on satisfaction with and the intention to use the technique were investigated.

Contrary to our expectations, the results of the experiments reveal that the impact of the RePro technique on *productivity* is either small or not significant. Moreover, the impact of the technique on the *number of original ideas* generated is mixed. However, in line with our expectations, the results in both lab experiments show that the RePro technique enables users to generate *more high-quality* ideas than individual brainstormers. When measuring idea diversity on a fine-grained level, results in both experiments also turn out that the RePro technique enables users to generate *more diverse* ideas than individuals using traditional brainstorming. Furthermore, users of the RePro technique were consistently *more satisfied* with their technique than individual brainstormers and *intend to use* the technique in future projects.

Notwithstanding these predominantly positive findings, our follow-up analysis suggests that the usage style of the RePro technique strongly affects the workshop outcomes. With the exception of the satisfaction with and the intention to use the technique, all outcome measures in both experiments are affected by the usage style. In particular, follow-up analysis results consistently show that *only* adopters of an *opportunity-centric* category-by-category application scheme generated *more diverse*, *more high-quality*, and *more original ideas* than individual brainstormers. RePro participants adopting a *problem-centric* generation style did not significantly perform better than individual brainstormers on any of the outcome measures and performed significantly worse than *opportunity-centric* adopters on all outcome measures except satisfaction with and intention-to-use the technique. The observed differences between the two styles regarding the output-related outcome measures are in line with (Coskun et al. 2000). In this study, it was found that presenting categories of solutions sequentially supports individuals in generating more ideas. The authors argued that a simultaneous presentation of solution categories may overwhelm individuals and prevent them from focusing attention adequately on each prime. Similarly, a *problem-centric* screening of the complete list of RePro principles is likely to prevent a thoughtful consideration of each principle. As an additional explanation, it is reasonable to expect that individuals who relentlessly focus on searching solutions *for problems* just lose sight of many attractive opportunity-driven solutions.

The promising results of the *opportunity-centric* usage of the RePro technique call for a study that investigates its impact on outcome measures in a controlled setting where participants are more strongly guided to adopt the style. Recall that RePro's *problem-centric* and *opportunity-centric* usage group in both experiments are non-randomized, post-hoc groups. Consequently, identified effects in our follow-up analysis are not free of a possible selection bias. In order to prevent such a bias, it is necessary that all experiment participants are randomly assigned to the different groups. Additionally, it is required that members in each group are guided to adopt a certain style. For example, automated tool support that offers the RePro principles piecemeal, i.e. category-by-category, might be used to guide participants in adopting an *opportunity-centric* usage style of the RePro technique. Such controlled experiments make it possible to investigate whether also individuals that have a natural tendency to select a *problem-centric* style are able to profit from using the technique in an *opportunity-centric* manner. In order to obtain even more detailed insights, outcome effects in these experiments can be investigated while taking into account potential moderators, such as a participant's personal need for structure (Neuberg and Newsom 1993; Rietzschel et al. 2014).

Whereas adopters of an *opportunity-centric* style clearly and consistently outperformed *problem-centric* adopters in terms of all output-related outcome measures, results in both experiments do not suggest that the usage style of the RePro technique affects the satisfaction with and intention to use the technique. Apparently, participants adopting a *problem-centric* style are still satisfied with the technique and intend to use the technique in future projects. In post-experiment interviews, participants adopting this style mentioned that the RePro technique supported them in coming up with ideas that were different from familiar directions. Despite that expected effects of this mechanism on the diversity, quality, and originality of ideas generated were not identified in both experiments, we need to be cautious in ruling out such a mechanism. Given the low sample sizes in the follow-up tests, statistical power might have played a role. At the same time, we should also be cautious in ruling out other explanations. For example, it might be the case that positive perceptions are only caused by a so-called confirmation effect. By this we mean that the RePro principles might just confirm one's belief that he or she is generating an effective process improvement idea. Further experimental research with larger sample sizes in a controlled setting should investigate whether the benefits of using the RePro technique in a problem-centric way go beyond *perceived* benefits.

Finally, we wish to point out that, although the follow-up analysis results reveal highly consistent results among the two experiments, subtle differences between the two student groups can be noticed. In particular, effects of the opportunity-centric usage style on productivity and the number of high-quality ideas generated seem to be less strong for graduate students in Nursing & Midwifery than for graduate students in Industrial Engineering. A plausible explanation is that graduate students in Nursing & Midwifery are less familiar with the terminology of the RePro principles and may need additional practice with these principles in order to reap all the potential benefits. Further research is required to investigate whether providing additional training is able to achieve this.

Limitations

As mentioned earlier, an important limitation of both experiments is that our *follow-up analysis* is based on non-randomized, post-hoc groups. As a consequence, identified effects in this analysis might be attributable to differences between groups with regard to characteristics of its members. Hence, future experiments in a controlled setting are required, so that identified effects are free of a possible selection bias.

As an important limitation, we also have to note that our experiment participants were graduate students in Industrial Engineering and Nursing & Midwifery respectively. Both groups received only basic training in process modeling and analysis and did not possess detailed domain knowledge related to the process to be improved. Although these students are likely to be representative of novice process analysts or novice healthcare professionals involved in rethinking care processes, one should be careful in generalizing our results to the redesign community at large. To gain more insights into generalization possibilities, it is recommended to conduct experimental evaluations of the RePro technique that take into the account the level of domain knowledge and the degree of experience with process improvement as potential moderators.

6.6 Summary

Whereas many process improvement techniques have been developed during the last decades, little is known about the effectiveness of these techniques. The reported experiments can be seen as first endeavors to evaluate the performance of process improvement techniques in a controlled environment. In particular, we evaluated the Rethinking of Processes (RePro) technique, which relies on a set of 46 process improvement principles, and compared its performance with traditional brainstorming. The results of both experiments confirm the potential of using the RePro technique for generating process improvement ideas, but also suggest that the usage style of the RePro technique strongly affects its performance. Future experiments are recommended to investigate the effects of different usage styles of the RePro technique on outcome measures in more detail.

7

Conclusion

Chapter 7

Conclusion

In this chapter, we outline the main findings of the research presented in the previous chapters. We also explicitly reflect on the implications of these findings for academic researchers and practitioners. Finally, we address the main limitations of our work and conclude this thesis with several suggestions for future research.

This thesis has addressed the question how to support the generation of process improvement ideas for care processes (i.e. the rethinking of care processes). The preceding chapters present research that was conducted to support us in answering this question. This research was organized around three research questions and two parts (see Chapter 1 for an in-depth discussion). In the first part of this thesis, we focused on research question 1 and aimed at gaining insights into the status-quo regarding methodological support for rethinking care processes. The insights gained from answering research question 1 enabled us to position and ground the development of a new technique for rethinking care processes in the second part of this thesis. Moreover, these insights supported us in constructing a rigorous build and evaluation procedure for this new technique. In the second part of this research endeavour, we concentrated our efforts on building (see research question 2) and evaluating (see research question 3) this new technique.

In Section 7.1, we summarize, integrate, and discuss the main findings regarding the three research questions. The collective findings enable us to answer the main research question. Section 7.2 outlines the implications of these findings for academic researchers and practitioners. Section 7.3 provides the main limitations of this thesis. In Section 7.4, we conclude this thesis by offering several suggestions for future research.

7.1 Main findings

In this section, we start with answering the three research questions introduced in Chapter 1 of this thesis. Subsequently, we integrate all findings to answer the main research question: *How to support the generation of process improvement ideas for care processes?*

Part 1: Methodological support for rethinking care processes

RQ 1:	What is the status-quo regarding methodological support for rethinking care processes?

With regard to research question 1, we focused on two different aspects and related sub-questions:

RQ 1.1: *(a) What methods are available for rethinking care processes?*
(b) What opportunities can be identified for improving these methods?
RQ 1.2: *(a) What research procedures were followed to develop these methods?*
(b) What lessons can be learned from these procedures?

Research question 1.1

As an answer to research question 1.1.a, we developed a so-called methodological framework by means of a systematic literature review (Chapter 2), a cross-case analysis (Chapter 3), and a field study among consultancy firms (Chapter 3). This methodological framework was established by identifying six key choices to be made concerning a method for rethinking care processes: (1) the *aim* that explains the objectives to be achieved by generating process improvement ideas, (2) the human *actors* invited to participate, (3) the *input* specifying the information that is collected prior to generating process improvement ideas, (4) the *output* describing the artifacts that are the result of this redesign activity, (5) the *technique* that prescribes how to generate process improvement ideas, and (6) the *tool* defined as a software package that is able to support this redesign activity. For each of these elements of a method, the developed methodological framework contains an overview of categorized method options that might be chosen. For example, the *input* element contains 20 method options that are categorized into the following five input categories: (1) redesign requirements, (2) redesign limitations, (3) as-is process specification, (4) process weaknesses, and (5) redesign catalysts. Concrete instances of options in these categories can be found in Figure 7.1. For instance, the category *redesign catalysts* includes *benchmark process insights* and *technology developments* as options that provide inspiration for the creation of effective process alternatives.

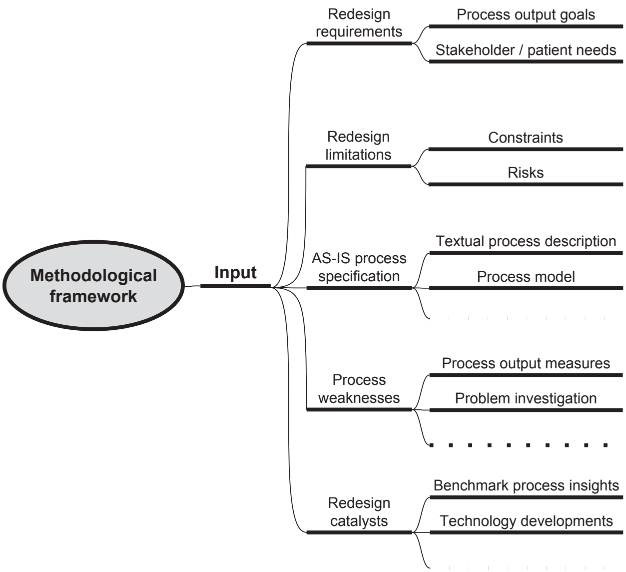


Figure 7.1. Snapshot input element of methodological framework.

The complete methodological framework contains 68 categorized method options: aim (9 options), actors (14 options), input (20 options), output (10 options), technique (10 options), and tool (5 options). The complete methodological framework, including definitions of all method options and related categories, can be found in Appendix B.5.

In order to answer research questions 1.1.b, we evaluated the method options that were selected by academic researchers to develop methods, as well as the method options used by practitioners as part of redesign initiatives. In this way, we observed several blind spots of existing methods and identified related improvement directions. Our five key observations are summarized below:

1) The usage of several promising redesign catalysts (e.g. benchmark process insights, medical guidelines, and technology developments) for rethinking care processes has received a limited amount of attention from academic researchers and practitioners. The smart integration of redesign catalysts in methods might enable a more complete exploration of process redesign possibilities and is worth further elaboration.
2) The methods developed and applied seem to have a strong internal / intra-company focus. Illustrative for this finding is the limited involvement of patients, suppliers, healthcare insurance commissioners, and external peers in rethinking care processes. Moreover, the absence of an explicit rethinking of the service concept, which determines the value proposition in the broader context of the value network, has to be noted in this realm. As a consequence of these limitations, process redesign initiatives are at risk of losing sight of many attractive process alternatives, such as self-service, outsourcing, and co-creation possibilities. To reap the benefits of process redesign projects to their fullest potential, future research is desirable that aims at gearing methods more towards an external / inter-company focus.
3) Academic researchers sometimes have investigated similar method options in a rather fragmented way. A case in particular concerns rule-based techniques. Rule-based techniques make use of generic process redesign rules that have accumulated in literature and practice to develop process alternatives (Chai et al. 2005; Nissen 2000; Reijers and Limam Mansar 2005). When studying these rules, researchers in the field of information systems have typically limited their attention to the “BPR best practices” literature, whereas researchers in the management sciences domain have focused on “TRIZ innovation principles”. An exploration of synergy / integration possibilities is recommended.
4) The physical lay-out of processes is an underestimated aspect in existing scientific methods for rethinking care processes. In manufacturing engineering (Hopp and Spearman 2008), the interplay between the physical arrangement of equipment and process design has attracted interest from many researchers. By contrast, existing methods for rethinking care processes do not include the physical lay-out as an important input or output element. A plausible explanation might be that many of the methods developed for rethinking processes are biased towards an application in the administrative domain, where digital instead of physical transfers dominate (Reijers and Limam Mansar 2005). Consequently, as part of the customization of methods for healthcare, an interesting avenue for future research is to investigate how the interplay between the design of the physical lay-out and other aspects of the process can be adequately addressed.
5) The uptake of advanced techniques has been very limited in healthcare. Such techniques offer a work procedure that specifies how to move from current process

insights (as-is) to concrete improvement ideas (to-be) and might additionally include guidance regarding the kind of process alternatives to be considered. A potential cause for the limited uptake of these techniques is that the evidence in favor of these techniques is largely anecdotal in nature. During interview sessions with external process consultants, it became apparent that, in particular, the potential of rule-based techniques attracts the interest of consultants. Hence, further elaboration and evaluation of these techniques is desired.

The presented list of improvement directions provided input for the selection of the research challenge addressed in the second part of this thesis. In the subsection with findings of the second part of this thesis, we provide more detailed information with regard to the selected research challenge.

Research question 1.2

In order to answer research question 1.2, we analyzed the research procedures followed by the scientific studies that were used to develop the initial version of the methodological framework (Chapter 2). A large majority of these studies aimed at introducing a new method for rethinking processes. Furthermore, several studies focused on reviewing other methods or studying success factors of redesign initiatives.

Related to research question 1.2.a, the analysis results reveal that numerous labels have been used by researchers to refer to the redesign of care processes. These labels include Business Process Reengineering, Business Process Redesign, Business Process Improvement, New Service Development, Clinical Pathways, and Lean Six Sigma.

In line with prior research (Hevner et al. 2004; March and Smith 1995), the analysis of the research designs of the studies introducing a new method led us to distinguish a build and evaluation phase. With regard to the build phase, the analysis results reveal that researchers have rarely used research method types other than literature reviews to construct new methods. During the evaluation phase, case studies and illustrations have usually been applied. In fact, only one study made use of another research method, i.e. formal analysis. Regarding method review and success factor studies, the analysis results indicate that literature reviews and field surveys are the research methods applied by the large majority of the studies.

Based on a critical evaluation of the research procedures outlined above, we were able to outline several lessons learned and to answer research question 1.2.b. These lessons learned are discussed below:

1) Academic researchers and healthcare professionals who restrict their attention to a limited number of management philosophies and related labels are vulnerable to overlooking valuable literature. Illustrative for this finding is that prior literature reviews that focused on the labels “Business Process Improvement” (Zellner 2011) and “Lean” (Mazzocato et al. 2010) do not cover any of the most advanced techniques for rethinking processes, e.g. rule-based and case-based techniques. Hence, anybody interested in the state-of-the-art with regard to methodological support for rethinking care processes is recommended to explore a broad spectrum of labels.
2) Academic researchers have used a limited number of research methods for building and

evaluating new methods. With respect to the build phase, researchers have almost exclusively focused on literature reviews, whereas field studies might also be used to identify improvement directions for existing methods. With regard to the evaluation phase, other research methods might be of interest as well. Many studies do not include an evaluation mechanism or merely provide an illustration of how the method can be applied. Case studies are only part of a small majority of the studies introducing a new method. These case studies include an evaluation of a method, but do not allow for a comparison of a method's performance with the performance of an alternative method. Thus, benefits attributable to the method applied remain hard to determine. Lab or field experiments offer opportunities for comparing the performance of different methods in a controlled environment and are worth further investigation.

3) In particular, studies introducing a new method lack information regarding data collection and analysis strategies. Remarkably, none of the literature reviews and only a minority of the case studies that are discussed in these studies include a discussion of data collection and analysis strategies. For example, in case studies it would be reasonable to expect information to be present about evaluation metrics and subject groups involved in evaluating a method (Davidoff et al. 2008; Hevner et al. 2004; March and Smith 1995). In the absence of this information, many opportunities for learning about method build and evaluation procedures are lost. Moreover, method limitations do not become fully transparent, which prevents fellow researchers from developing methods that are geared towards resolving these limitations. Hence, an improved explanation of data collection and analysis strategies is desirable to advance research in this area.

The presented list of lessons learned supported us in constructing a rigorous build and evaluation procedure in the second part of this research endeavor. More detailed information is provided in the next subsection.

Part 2: The Rethinking of Processes (RePro) technique

Answering research question 1.1.b led to the identification of multiple research challenges requiring further investigation. Based on the expected improvement potential and available expertise in our research group, we decided to concentrate our research efforts on building and evaluating a new *technique* for rethinking care processes in the second part of this thesis. This challenge directly relates to the third and fifth improvement direction. As part of our development efforts, we also incorporated elements related to the second improvement direction by making an explicit rethinking of the service concept part of the technique. In a similar vein, we incorporated elements related to the fourth improvement direction by developing a technique that covers the physical lay-out aspect.

Answering research question 1.2.b led to an overview of multiple lessons to be learned with regard to building and evaluating methods. All these lessons were taken into account while determining the build and evaluation procedures for the new technique. In particular, a systematic literature review (Chapter 2), a cross-case analysis (Chapter 3), and a field study among consultancy firms (Chapter 3) provided input to build the new technique. As part of the building procedure, we made use of a Delphi technique (Chapter 4). Moreover, a cross-case analysis was conducted (Chapter 5) and an applicability check with potential end-users (Chapter 5) was carried out to further improve the technique. Finally, two lab experiments (Chapter 6) were conducted to evaluate the performance of the technique. Thus, we made use of a wide variety of complementary research methods to establish a rigorous construction and evaluation of the technique. With regard to the systematic literature review, the cross-case analyses, and the field study among consultancy firms, we tried to cover insights from all relevant management philosophies. Furthermore, we tried to be as transparent as possible with regard to all applied data collection and analysis strategies.

RQ 2: What new technique can be developed to support a more complete exploration of process improvement possibilities for care processes?

As an answer to research question 2, we constructed (Chapter 4) and fine-tuned (Chapter 5) the Rethinking of Processes (RePro) technique by applying a wide variety of research methods as mentioned above.

The RePro technique supports healthcare practitioners in a workshop setting to generate process improvement ideas that aim at, for example, reducing processes' costs and throughput times, as well as improving patient satisfaction. Practitioners can be either external or internal process analysts with an educational background in process management or senior healthcare professionals with a medical background.

The RePro technique aims to support healthcare practitioners in a more complete exploration of redesign possibilities as compared to traditional brainstorming. Traditional brainstorming is often used in practice to rethink care processes. However, this technique does not include a solution for the personal inertia to search for process improvement ideas that are different from familiar directions (Chai et al. 2005). In this way, the full redesign potential is not achieved in terms of reducing processes' costs and throughput times, as well as improving patient satisfaction. To enable a more complete exploration of process improvement possibilities, the RePro technique includes two components: (1) a set of process improvement principles providing concrete guidance regarding the kind of process improvement ideas that can be considered, and (2) an application procedure supporting healthcare practitioners in a systematic screening of the principles. In Chapter 4, more detailed information can be found with respect to the design choices made regarding the RePro technique. In addition, a comparison of its characteristics with the characteristics of potential other alternatives for the traditional brainstorming technique (e.g. repository-based techniques) can be found in this chapter. Below, we only briefly describe the two components of the RePro technique.

All RePro principles can be seen as solutions that have previously been applied and seem worthwhile to reproduce in another situation or setting. Examples of these principles are "prior counteraction" (add tasks to prevent the occurrence of an undesirable situation or to reduce its impact) and "trusted party" (instead of determining information oneself, use results of a trusted party). The set of RePro principles is largely based on the systematic comparison and integration of two groups of principles that provide complementary insights into how care processes can be improved: BPR best practices, which primarily support rethinking administrative processes (Reijers and Limam Mansar 2005), and TRIZ innovations, which in their original form provide support for innovating products (Chai et al.

2005). All 46 RePro principles are organized into nine categories that address different aspect of a process that can be improved: the contacts with *customers,* the collaboration and communication with parties in the *external environment*, the *tasks* that are part of the process, the *task order and timing*, the number and types of available *human resources / facilities, equipment*, *and material* and their allocation to tasks, the usage and creation of *information* in the process, the usage of *information and communication technology*, and the arrangement of the *physical lay-out*. By addressing a wide variety of redesign opportunities, the set of RePro principles aims to assist healthcare practitioners in a more complete exploration of the full range of process improvement possibilities as compared to traditional brainstorming.

The application of the set of RePro principles is supported by an application procedure describing how the principles can be applied (see Figure 7.2). The application procedure is based on the nominal group technique (Van de Ven and Delbecq 1974) and the multi-level design approach (Patrício et al. 2011). The nominal group technique offers an effective procedure for groups of individuals that are faced with an idea generation task. This procedure is characterized by silent individual idea generation followed by sharing, discussing and ranking ideas. In this way, the technique overcomes negative group dynamics (e.g. production blocking) (Diehl and Stroebe 1987).

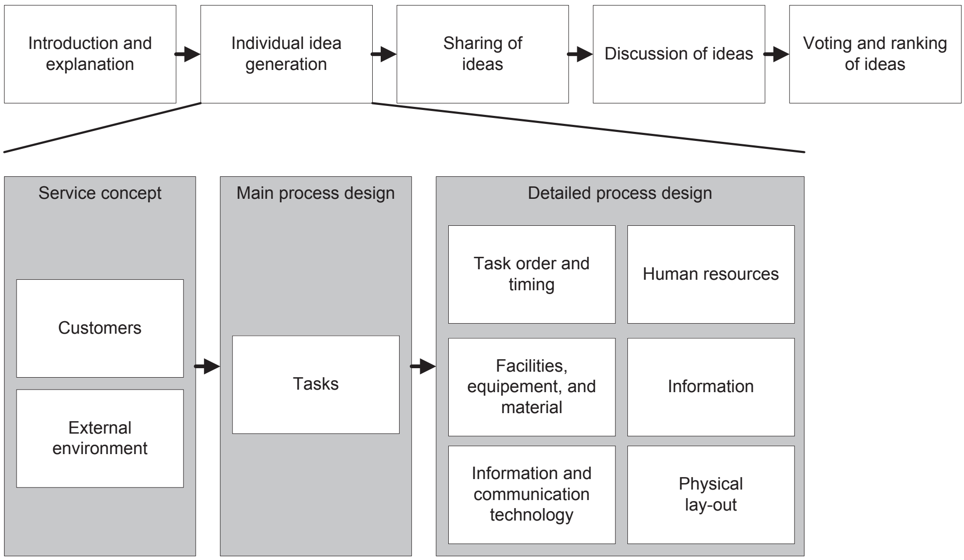


Figure 7.2. Application procedure of RePro technique.

The multi-level design approach assumes that service systems can be designed at different levels of abstraction (Patrício et al. 2011). Based on this assumption, it offers a mechanism to separate concerns and to improve the usability of the large number of principles. In particular, it led us to assign all RePro principles to three levels that can be considered successively: the *service concept*, the *main process design*, and the *detailed process design*. The *service concept* level includes principles that are related to the positioning of the process in relation to its customers / patients and third parties. All principles of the customers and external environment category are assigned to this level, e.g. control relocation (move controls towards the patients) and outsourcing (consider outsourcing a business process as a whole or parts of it). At the *main process design* level, principles of the task category are considered, which are related to the activities that have to be executed to fulfill the needs of the customers. Examples of these principles are task elimination (eliminate unnecessary tasks from the business process) and prior action (perform tasks before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process). The *detailed process design* level focuses on the "when, who, with what, where" aspects of task execution. Principles considered at this level belong to the task order and timing, human resources, facilities, equipment, and material, information, information and communication technology, and physical lay-out category. The parallelism (consider whether tasks may be executed in parallel) and case manager (appoint one person as responsible for the handling of a patient) principles are illustrative examples. The three different levels separate concerns while rethinking care processes and support healthcare practitioners to apply the principles in an effective way.

RQ 3: How does the newly developed technique perform compared to traditional brainstorming?

In order to answer research question 3, we conducted two lab experiments (Chapter 6) to evaluate the RePro technique and compared its performance with traditional brainstorming. In particular, we compared the performance of these two techniques with regard to *individual idea generation* (see Figure 7.2). This step is considered to be a crucial step in business process redesign initiatives and distinguishes the RePro technique most clearly from other techniques.

The experiment task in both experiments was to generate process improvement ideas for a cataract surgery process based on a realistic case description. The two lab experiments had a similar set-up. However, the participants who were recruited differed. Participants of the first experiment were 89 graduate students in Industrial Engineering. In the second experiment, 72 graduate students in Nursing & Midwifery participated.

The results of the two experiments indicate that the RePro technique is an attractive alternative for traditional brainstorming. Only with regard to productivity and originality, the results provide mixed support for our hypotheses. In particular, only in the first experiment individuals generated *more* and *more original* ideas than individual brainstormers. Regarding all other outcome measures, the results in both experiments provide support for our hypotheses. In line with expectations, results consistently show that the RePro technique enables users to generate *more high-quality* ideas than individual brainstormers. When measuring idea diversity on a fine-grained level, results in both experiments also reveal that the RePro technique enables users to generate *more diverse* ideas than individuals using traditional brainstorming. Furthermore, users of the RePro technique were consistently *more satisfied with their technique* than individual brainstormers and *intend to use* the technique in future projects.

Notwithstanding these predominantly positive findings, follow-up analysis results suggest that the usage style of the RePro technique strongly affects the workshop outcomes. In this follow-up analysis, we distinguished the following two styles of using the RePro technique (see Figure 7.3):

1) *Opportunity-centric (OC)* generation: Adopters of the opportunity-centric generation style take the RePro principles as a starting point to generate process improvement ideas. They go through these principles category by category to identify application opportunities.
2) *Problem-centric (PC)* generation: Adopters of problem-centric generation style take the problem areas as identifiable in the process as a starting point. For identified process weaknesses, they screen the list of principles each time to identify relevant solutions.

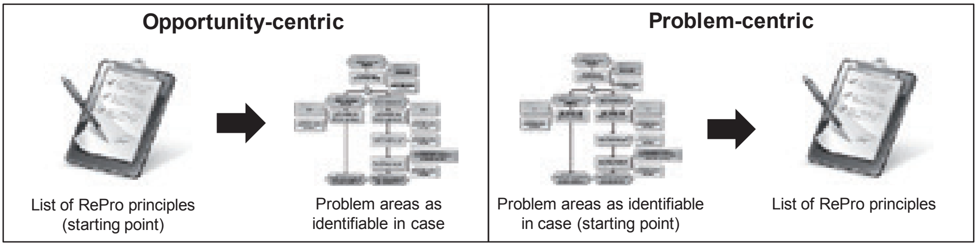


Figure 7.3. Usage styles RePro technique.

With the exception of the satisfaction with and the intention-to-use the technique, the two usage style groups score differently regarding the outcome measures. In particular, follow-up analysis results consistently reveal that *only* individuals adopting an *opportunity-centric* style of the RePro technique generated *more diverse*, *more high-quality*, and *more original* ideas than individual brainstormers. Participants adopting a *problem-centric* generation style did not significantly outperform individual brainstormers on any of the outcome measures and performed significantly worse than *opportunity-centric* adopters on all outcome measures except satisfaction with and intention-to-use the technique. A plausible explanation for the observed differences between the two styles of using the RePro technique is that a *problem-centric* screening prevents individuals from adequately focusing attention on each principle. Moreover, it is not unreasonable to expect that individuals with a relentless focus on finding solutions *for problems* risk missing many attractive opportunity-driven solutions. However, future experimental research is required to study the effects of the different usage styles in more detail. Note that the follow-up analysis discussed above is based on non-randomized, post-hoc groups. Hence, a selection bias cannot be ruled out. This implies that identified effects might also be attributable to differences between groups with regard to characteristics of its members (e.g. degree of task motivation). A random assignment of participants to groups in future experiments is needed to prevent a selection bias. Moreover, it is required that members in each group are guided to adopt a certain style (e.g. by making use of a tool). Only by forcing individuals to adopt, for example, an opportunity-centric style in these experiments, can it be investigated whether individuals who have a natural tendency to select a *problem-centric* style are also able to profit from adopting the *opportunity-centric* style of the RePro technique.

The findings per research question presented above enable us to answer the main research question:

RQ:	*How to support the generation of process improvement ideas for care processes?*

Whereas many methods have been developed over the last decades that can be used to rethink care processes, little is known about the effectiveness of these methods and several improvement directions can still be identified. In this thesis, we concentrated our efforts on building and evaluating a new *technique* for generating process improvement ideas for care processes, i.e. the Rethinking of Processes (RePro) technique. The reported experiments in the thesis can be seen as first endeavors to evaluate the performance of process improvement techniques in a controlled environment. In particular, we focused on comparing the performance of the RePro technique and traditional brainstorming in these experiments. The results confirm the potential of using the RePro technique for generating improvement ideas for care processes, but also suggest that the usage style of this technique strongly affects its performance. Future experiments are required to provide healthcare practitioners with concrete advice regarding how to apply the RePro technique to reap the benefits of this technique to its fullest potential.

7.2 Implications

In this section, we outline the implications of our main findings for academic researchers as well as practitioners.

7.2.1 Implications for academic researchers

The methodological framework developed and related critical evaluation support academic researchers in grounding and improving methods for rethinking care processes (see main findings related to research question 1.1). In particular, the methodological framework developed enables them to base their development efforts on an overview of existing method options. As such, we also allow academic researchers to position their development efforts and encourage them to explore synergy options among development initiatives. The methodological framework is complemented with directions for further method development. In this way, academic researchers are provided with concrete and traceable advice with regard to developing future methods for rethinking care processes. To what extent academic researchers and practitioners active in application domains other than healthcare might profit from the methodological framework and related directions for further method development is addressed in Section 7.4.

In this thesis, academic researchers can also find several suggestions with regard to constructing rigorous build and evaluation procedures for new methods (see main findings related to research question 1.2). Besides these generic recommendations, we also hope to have shown that a lab experiment offers an attractive alternative to a traditional case study, as it enables a more rigorous evaluation of the benefits attributable to process improvement techniques in a controlled setting.

This thesis also introduces a new technique for rethinking care processes, i.e. the Rethinking of Processes (RePro) technique (see main findings related to research question 2). This technique includes two innovations: (1) an integration of two groups of process improvement principles, and (2) a procedure that guides practitioners applying the principles in a systematic way. We invite fellow researchers to further develop and evaluate this promising technique. Concrete directions in this regard are provided in Section 7.4. In this section, we also briefly elaborate on the potential of the technique in application domains other than healthcare.

As a final point, the results of the follow-up analysis of the experiments leave academic researchers with important insight into the potential impact of the usage style of a technique on outcome measures (see main findings related to research question 3). The results imply that - in addition to evaluating which technique is effective in a certain context - it is important to investigate how exactly individuals or groups adopt techniques, as their usage style might be an important determinant of success.

7.2.2 Implications for practitioners

Due to its identification of important choices to be made regarding a method for rethinking care processes and a comprehensive overview of available options, the methodological framework also provides solid and useful support for any healthcare practitioner composing a respective method. More specifically, the framework enables them to make choices based on the options offered by existing methods in the information systems, management sciences, and health sciences domain. It should be emphasized that it still is desirable to enrich the methodological framework with future insights related to the effectiveness of different method options in order to enable practitioners to make evidence-based choices.

This thesis also offers healthcare professionals and process consultants the RePro technique as a concrete technique for generating process improvement ideas for care processes. Lab experiment results confirm the potential of the RePro technique to support healthcare practitioners in generating process improvement ideas. However, results also suggest that the way the RePro technique is used has a major impact on the productivity, diversity, quality, and originality of ideas generated. Particularly, the results lead us to speculate about the promising potential of adopting an *opportunity-centric* generation style (see Figure 7.3). Further experimental research, however, is needed to provide healthcare professionals and process consultants with evidence-based suggestions about how to use the RePro technique.

7.3 Main limitations

Inevitably, there are several limitations to our research. In the preceding chapters, we have already discussed several limitations of specific studies. Some of these limitations were addressed in follow-up studies. For example, the cross-case analysis and field study among consultancy firms in Chapter 3 targeted a limitation of Chapter 2, namely that the initial methodological framework was solely based on scientific reports. Here, we only discuss several limitations that are relevant in the context of our final research deliverables and outcomes given our selected research scope. Suggestions for future research are outlined in

Section 7.4, which among other things address options for further method development and evaluation in healthcare, as well as other application domains.

With regard to the methodological framework, we used a cross-case analysis and field study among consultancy firms to enrich the initial methodological framework with insights from method *applications* in healthcare (Chapter 3). We wish to note that the cross-case analysis targeted *hospital* case studies published in *scientific* journal or conference papers. Although a hospital context is generally considered to be the most challenging environment from a process improvement perspective (Vissers and Beech 2005), we should be careful in assuming that the framework developed also is representative of methods in other healthcare contexts. Moreover, the bias towards scientific sources makes it difficult to generalize the representativeness of the methodological framework to projects with an exclusively practical objective. To prevent severe biases, we complemented the cross-case analysis with a field study among consultancy firms. Nonetheless, the methodological framework can certainly be enriched by considering initiatives in practice that target cross-organizational healthcare processes or processes in a non-hospital environment.

In order to improve the design of the RePro technique, we also made use of two research methods that were restricted in scope. Specifically, a cross-case analysis and an applicability check with potential users were conducted (Chapter 5). The cross-case analysis focused on initiatives that targeted perioperative processes, i.e. processes that consist of the steps that are performed just before, during and after surgery. However, one group of participants of the applicability check was formed by nurses involved in executing activities that are part of these processes. Given their characteristics (e.g. intensive (physical) patient involvement throughout the process), perioperative processes formed a suitable development ground for the RePro technique. However, the bias towards perioperative processes implies that the RePro technique - in particular the set of RePro principles - can be further improved by investigating its potential for other kinds of care processes, e.g. diagnostic pathways in an outpatient setting.

As final limitations of our research, we would like to mention two limitations of the experiments that were conducted to evaluate the RePro technique (Chapter 6). Firstly, as mentioned earlier (see Section 7.1), an important limitation of both experiments is that our *follow-up analysis* is based on non-randomized, post-hoc groups. Consequently, identified effects are not free of possible selection bias. Future experiments in a controlled setting are required to prevent this bias and to gain actual insights into the effects of adopting a certain usage style of the RePro technique. Secondly, participants in our experiments were graduate students in Industrial Engineering and Nursing & Midwifery respectively. Both groups of participants did not possess detailed domain knowledge related to the process to be improved and received only basic training in process modeling and analysis. Although these students are likely to be representative of novice process consultants or novice healthcare professionals involved in rethinking care processes, we should be cautious in generalizing our findings to the redesign community at large. To gain more insights into the generalizability of the findings, experimental evaluations of the RePro technique are recommended that take into account potential moderators, such as the level of domain knowledge and the degree of experience with process improvement.

7.4 Future research

The research presented in this thesis leaves us with many directions for future research. Several directions that are worth considering are outlined below.

Firstly, an examination of the developed methodological framework reveals that many method choices can and have to be made regarding rethinking care processes. As mentioned earlier, we expect that the explicit examination of this comprehensive framework can assist healthcare practitioners in making well-considered method choices. Future research is required to investigate the benefits as well as shortcomings of its explicit usage to compose methods for rethinking care processes in practice. Preferably, this investigation should also include an evaluation of the framework in the context of initiatives targeting cross-organizational care processes or care processes in a non-hospital environment. This investigation might even go beyond the healthcare domain. Note that - given the scarcity of methods that are customized for the health domain - we also reviewed *application domain-independent methods* and related success factors to create the methodological framework. As a consequence, most of the method options in the framework are not specific to the healthcare domain. This suggests that the methodological framework might also be used as a useful starting point for supporting practitioners in other application domains, such as banking, insurance, government, manufacturing, warehousing, and logistics. Certainly, the methodological framework can be enriched with insights from *application domain-specific* methods in these domains.

Secondly, the experimental evaluations of the RePro technique ask for further research with regard to how the technique should be applied in the context of individual idea generation. The follow-up analysis results of the two conducted experiments suggest that the adopted style (i.e. *opportunity-centric* vs. *problem-centric* generation) has a major impact on workshop outcomes. As mentioned earlier, future experiments are required to investigate the adoption of these styles in a controlled setting, so that identified effects are free of a possible selection bias. In these experiments, we suggest taking potential moderators into account, such as personal need for structure, the amount of training in the RePro technique, the level of domain knowledge, the degree of experience with improving processes, and the complexity of the process to be improved. In this way, we might be able to provide more customized advice regarding how to use the RePro technique.

Thirdly, we also recommend extending the experimental evaluation to the complete group procedure of the RePro technique. So far, we have focused on the individual idea generation step as it most clearly distinguishes the RePro technique from other creativity techniques. However, it would be interesting to investigate to what extent group dynamics have a positive or negative impact on the set of ideas that results after the discussion round. In a similar vein, it is worthwhile to evaluate whether the voting and ranking procedure ultimately results in the selection of an improved set of ideas.

Fourthly, in addition to conducting follow-up experimental evaluations of the current version of the RePro technique, it is worthwhile to explore possibilities to further improve the RePro technique. Especially, future research is required to investigate the most appropriate way to discuss, vote, and rank the ideas as part of the complete application procedure. For example, the benefits offered by multi-criteria evaluation procedures might be studied in this regard (e.g. Baltussen and Niessen 2006; Lohrmann and Reichert 2015). Besides this, with regard to the individual idea generation step, several variants on the application procedure are interesting to investigate. For instance, a variant could be considered in which principles on the third level (detailed process design level) are further divided into two or more chunks of related categories of ideas. These chunks of principles can then be investigated by different groups of individuals. Such a variant separates concerns even more and might allow for a more effective screening of principles. Moreover, the set of RePro principles can still certainly be enriched. For example, principles in the physical lay-out category can be further extended and concretized by investigating principles applied in areas such as warehousing design (e.g. Cormier and Gunn 1992; Rouwenhorst et al. 2000). Besides, recent work by Lohrmann (2015) offers a comprehensive overview of business process quality attributes, which enables further enrichment of the set of RePro principles. Lohrmann's (2015) quality attributes are deduced from a general business process quality definition. As discussed by Lohrmann (2015), some of these quality attributes, such as the one stating that task automation potentials should be utilized reasonably, are highly similar to existing process improvement principles. Other quality attributes are not yet covered by the existing set of RePro principles. Hence, further research is desirable to investigate whether additional principles for the set of RePro principles might be derived from the set of quality attributes.

Fifthly, we wish to point out that a *technique* is just one of the six elements of a method for rethinking processes. This implies that future research is also still needed to support practitioners to compose a comprehensive method based on the RePro technique. In order to provide this support, an investigation is required of how choices with regard to the other method elements influence the effectiveness of the RePro technique. For example, we invite fellow researchers to investigate to what extent the availability of process output goals and process models of the as-is process influence its effectiveness. Besides the fact that several method choices are likely to influence the effectiveness of the RePro technique, we also foresee that some of these choices might even require adaptations of the RePro technique. For instance, the selection of benchmark process insights as input demands an additional step in the application procedure in which these insights are explicitly considered. In such cases, identifying the most effective adaptation of the application procedure, e.g. considering benchmark process insights before or after individual idea generation based on RePro principles, requires further research.

Sixth and finally, another avenue for future research is the application potential of the RePro technique in application domains other than healthcare. As mentioned earlier, administrative processes meet patient-logistic processes in the healthcare domain (Mans et al. 2009; Mans et al. 2013). As a consequence, we expect that the application potential of the RePro technique is not necessarily restricted to this domain. It is reasonable to expect that sectors such as banking, insurance, and government, where administrative processes are omnipresent, might directly profit from adopting the technique. Future research should investigate whether it is desirable to develop a more compact set of RePro principles for these sectors (e.g. by leaving out principles of the categories facilities, equipment, and material and physical lay-out). Even the potential of the RePro technique to improve material-logistic processes in sectors such as manufacturing, warehousing, and logistics is worth further investigation. With regard to these domains, future research is particularly recommended to study whether the set of principles can be further enriched with application domain-specific principles.

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Summary

Summary

Rethinking care processes: Does anybody have an idea?

Many healthcare organizations are being challenged to cure more people with fewer resources, while satisfying strict quality and safety regulations. This challenge has led to a growing interest in care process redesign projects, as these projects have substantial potential in terms of reducing processes' costs and throughput times, as well as improving patient satisfaction.

Care processes often include several consultations, diagnostic tests, and treatments, as well as supporting steps, such as scheduling. A typical process redesign project that targets these end-to-end processes consists of describing the as-is process, conducting an analysis of the as-is to identify process weaknesses, generating process improvement ideas (i.e. rethinking the process), and implementing the new process. In these projects, redesign teams typically spend much time describing and analyzing the as-is situation systematically. By contrast, process improvement ideas are often generated in one or a few workshops using a highly intuitive approach. For example, starting from a set of process improvement goals and an analysis of the as-is process, actors merely brainstorm about process improvement ideas during several sessions. These sessions are often chaired by an external consultant who frequently raises the question: “Does anybody have an idea?” Such a highly intuitive approach does not include a safeguard to guarantee a systematic and complete exploration of the full range of redesign options. Consequently, these intuitive approaches run the risk of leading to biased choices and may neglect attractive redesign options. As such, the improvement potential of many care process redesign initiatives is not fulfilled. This leads us to ask the question: “Does anybody have an idea regarding a better approach to rethinking care processes?”

As argued by several researchers, method-ism that ensures a more complete exploration of the potential solution space might be highly beneficial to the creative act of generating process improvement ideas. In the first part of this research endeavor, we investigated the status-quo with regard to methodological support for rethinking care processes. By means of this investigation, we gained insights into potential alternatives for the often-applied, highly intuitive approach. A systematic literature review, a cross-case analysis, and a field study among consultancy firms were conducted towards this end. The main result of this part of the thesis is a so-called methodological framework. This methodological framework was established by identifying six key methodological decision areas with regard to the act of generating process improvement ideas: (1) the aim that explains the objectives to be achieved by this act, (2) the human actors invited to participate, (3) the input specifying the information that is collected prior to this act, (4) the output describing the artifacts that are the result of this act, (5) the technique that prescribes how to generate process improvement ideas, and (6) the tool defined as a software package that is able to support this act. For each of these methodological decision areas, the methodological framework developed contains an overview of categorized method options. A method option can be seen as a concrete type of objective, actor, or artifact that might be chosen in the context of composing

a method. For example, a medical guideline is an example of an input-related method option that can be collected prior to the act of rethinking care processes. By providing a categorized overview of method options per decision area, the framework supports practitioners in composing a well-considered method based on the options offered by existing methods. Moreover, it facilitates academic researchers to ground and improve methods for generating process improvement ideas.

Based on a critical analysis of the methodological framework, we decided to develop and evaluate a new technique for generating care process improvement ideas in the second part of this research endeavor. This technique, i.e. the Rethinking of Processes (RePro) technique, integrates and extends existing techniques for rethinking processes. It relies on a set of process improvement principles. All these RePro principles can be seen as solutions that have been applied previously and seem worthwhile to reproduce in another situation or setting. Examples of these principles are “parallelism” (consider whether tasks can be executed in parallel) and “reconstruction” (consider reconstructing the physical arrangement of the process). The RePro technique includes a procedure that guides practitioners in applying the 46 RePro principles. This procedure is characterized by silent individual idea generation followed by sharing, discussing and ranking ideas. In addition to enabling multiple healthcare practitioners to work together on the idea generation activity, the application procedure supports practitioners in dealing with the large number of principles by separating concerns. In particular, all RePro principles are assigned to three levels that can be considered successively: service concept, main process design, and detailed process design.

An initial version of the RePro technique was evaluated by means of a cross-case analysis and an applicability check with two different groups of potential end-users (i.e. senior healthcare professionals and process consultants) to fine-tune its design. Moreover, two lab experiments, which each focused on a different end-user group, were conducted to compare the performance of the RePro technique and traditional brainstorming. Among other things, we evaluated the performance of these techniques with regard to the diversity and the number of high-quality ideas generated. The results of both experiments confirm the potential of using the RePro technique for rethinking care processes, but also suggest that the way the technique is used strongly affects its performance.

About the author

About the author

Rob Vanwersch was born on 21 July, 1984. He received a BSc degree (cum laude) in Industrial Engineering & Management Sciences at Eindhoven University of Technology in 2005 and a MSc degree (cum laude) in Operations Management & Logistics at the same university in 2007. He conducted his Master's thesis project during an internship at the Catharina Hospital in Eindhoven. His Master's thesis project focused on business process redesign in healthcare. The results of this study formed the basis for his later PhD research.

After finishing his studies, Rob started working at Maastricht University Medical Center on the intersection of finance and process management. In 2010, he received a grant from Maastricht UMC for a six-year part-time PhD project on the generation of process improvement ideas for care processes. He conducted his PhD project within the group of Information Systems of the Department of Industrial Engineering & Innovation Sciences at Eindhoven University of Technology. As part of his PhD project, Rob cooperated intensively with several consultancy organizations and healthcare institutes, as well as various (international) scientists and students. At the same time, he led a program team on Operational Excellence at Maastricht UMC, which enabled him to bring research findings into practice. The results of his PhD project are presented in this dissertation.

List of publications

List of publications

Publication related to this thesis

Hulsebos, M. (June 2014). Intuïtie alleen is een slechte raadgever. *Business Information Magazine*, pp.12-14.[20]

Netjes, M., Mans, R.S., Reijers, H.A., Aalst, W.M.P. van der, & Vanwersch, R.J.B. (2010). BPR best practices for the healthcare domain. In S. Rinderle-Ma, S. Sadiq, & F. Leymann (Ed.), *Business Process Management Workshops*. Paper presented at the 7th International Conference on Business Process Management, Ulm, 7 Sep 2009 (pp. 605-616). Berlin, DE: Springer.

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[20] This professional publication (in Dutch) was based on an interview with R.J.B. Vanwersch and M.C.S. Peters.

Vanwersch, R.J.B., Shahzad, K., Vanderfeesten, I., Vanhaecht, K., Grefen, P., Pintelon, L., Mendling, J., Van Merode, G.G., & Reijers, H.A. (2016). A critical review and framework of business process improvement methods. *Business & Information Systems Engineering*, *58*, 43-53.

Other publications

Mans, R.S., Van der Aalst, W.M.P., Vanwersch, R.J.B., & Moleman, A.J. (2013). Process mining in healthcare: data challenges when answering frequently posed questions. In R. Lenz, S. Miksch, & M. Peleg (Ed.), *Process Support and Knowledge Representation in Health Care*. Paper presented at the BPM Joint ProHealth 2012 / KR4HC 2012 workshop, Tallinn, 3 Sep 2012 (pp. 140-153). Berlin, DE: Springer.

Mans, R.S., Van der Aalst, W.M.P., & Vanwersch, R.J.B. (2013). *Process mining in healthcare: opportunities beyond the ordinary* (BPM Center Report No. BPM-13-26).

Mans, R.S., Van der Aalst, W.M.P., & Vanwersch, R.J.B. (2015). *Process mining in healthcare: evaluating and exploiting operational healthcare processes.* Berlin, DE: Springer.

Appendices

Appendix A.1

Boolean expressions systematic literature review Chapter 2

In this appendix, we explain the Boolean expressions of the systematic literature review that were used for searching potentially relevant studies.

The Boolean expressions were based on the research objective and derived from the thesaurus terms of three electronic databases, i.e. ABI/Inform, INSPEC, and Medline. With regard to the first part of the review, we selected “method”, “redesign”, and “process” as the core elements of the Boolean expression. “Factor”, “redesign” and “process” were selected as the core elements of the Boolean expression of the second part of the review. A structured scan of the thesaurus trees of all electronic databases was performed to discover related thesaurus terms for all these elements. After obtaining these terms, cross-checks were performed between the different electronic databases. In this way, possible undiscovered thesaurus terms during the initial scan were localized and identified. After obtaining the thesaurus terms, additional synonyms, antonyms, and abbreviations were identified by means of a general thesaurus, acronym library, and trial searches. Finally, advanced search options like Boolean operators and truncation symbols were used to construct the free text search term. We created the following Boolean expression with respect to the first part of the literature review:

(([process] AND [redesign]) OR [process redesign]) AND [method]

Regarding the second part of the literature review, the following Boolean expression was created:

(([process] AND [redesign]) OR [process redesign]) AND [factor]

Each part in the above Boolean expression surrounded by the ([ ]) symbol is itself a Boolean expression consisting of synonyms, acronyms, and abbreviations. For each part, the complete Boolean expression is shown in Table A.1.1.

Part	Complete Boolean expression
Process	business model: OR (care ADJ3 continuit:) OR (care ADJ3 continuum:) OR case management OR chain: OR delivery system: OR network: OR operation: OR order fulfil: OR order processing OR organi#ational model: OR pathway: OR patientflow: OR patient flow OR process OR processes OR product: line: OR service: OR workflow: OR work flow:
Redesign	chang: OR CI OR CQI OR CQM OR design: OR develop: OR engineer: OR improv: OR innovat: OR invent OR inventi: OR optim: OR Quality Management OR redesign: OR reengineer: OR re-engineer: OR reform: OR reorgani: OR restructur: OR streamlin: OR total quality OR TQM
Process redesign	BPR OR (clinical ADJ2 path:) OR (critical ADJ2 path:) OR disease management OR integrated delivery OR (integrated ADJ2 path:) OR kaizen OR lean OR (patient ADJ2 centered ADJ2 care) OR (patient ADJ2 focused ADJ2 care) OR six sigma
Method	approach: OR blueprint: OR guide: OR guidebook: OR handbook: OR instruction: OR manual: OR method: OR procedure: OR protocol: OR road map: OR technique: OR tool:
Factor	antecedent OR barrier: OR cause: OR challenge: OR determinant: OR enabler: OR factor: OR guideline: OR hurdle: OR issue: OR lesson: OR obstacle: OR recommendation: OR requirement: OR risk: OR rule:

Table A.1.1. Overview Boolean expressions of systematic literature review. The Boolean expressions in this table are used in the INSPEC and Medline database. In the ABI/Inform database slightly different truncation symbols are used.

The free text search in the title of the studies was complemented with the use of database specific headings. Specifically, we complemented the free text search with the use of high-level subject headings and classification codes in INSPEC and Mesh headings and sub-headings in Medline. Headings were not used in ABI/Inform due to the absence of a clear hierarchical tree structure of headings. Regarding the other electronic databases, the selection of headings was on the safe side of inclusiveness. The detailed search filters of the three electronic databases, including the selected headings, are shown in below.

General:

Date electronic searches:
27/07/2011

Date advisory committee consultation:
27/03/2012

ABI/Inform:

Filter settings advanced search:
- Database: ABI/INFORM GLOBAL
- Data range: after this data: 01/01/1990
- Limit results to: Scholarly journal, including peer-reviewed
- Exclude: Book reviews; Dissertations; Newspapers

INSPEC:

Filter settings multi-field search:
- English language
- Abstract
- Publication year: 1990 - Current
- Publication types: Conference paper; Conference Proceedings; Journal paper
- Subject headings:

- Systems analysis (not exploded)
    - Systems re-engineering
- Business process re-engineering
- Customer services
- Management of change
- Organizational aspects (not exploded)
- Production management (not exploded)
    - Process planning
    - Logistics
- Quality management (not exploded)
    - Total quality management
    - Continuous improvement
    - Six sigma (quality)
    - Innovation management
- Supply chain management (not exploded)
- Administrative data processing
- Operations research (not exploded)
- Order processing
- Management science (not exploded)
- Health care
- Patient care
- Systems engineering
- Production engineering
- Industrial engineering
- Value engineering
- Process design
- Optimal systems
- Constraint theory
- Constraint handling
- Lean production
- Benchmark testing

- Classification codes:
    - Systems theory applications in economics and business
    - Systems theory applications in industry
    - Business and administration (not exploded)
        - Office automation
        - Public administration
        - Medical administration
        - Manufacturing and industrial administration
        - Administration of other service industries
    - Business and professional IT applications
    - Health care applications of IT
    - Industrial and manufacturing applications of IT
    - General topics in manufacturing and production engineering (not exploded):
        - Management and business
        - Organizational aspects

        - Management issues
        - Information technology applications (not exploded)
            - Industrial applications of IT
            - Business applications of IT
    - Production management
    - Research and development
    - Design
    - Manufacturing systems
    - System theory applications

Medline:

Filter settings multi-field search:

- English language
- Abstract
- Publication year: 1990 - Current
- Mesh headings:
    - *Information sciences / Information science* / Systems analysis
    - *Health care / Health care facilities, manpower and services* / Capacity building
    - *Health care / Health care facilities, manpower and services* / Health facilities
    - *Health care / Health care facilities, manpower and services* / Health services
    - *Health care / Health care economics and organizations* / Health planning
    - *Health care / Health service administration* / Organization and administration
    - *Health care / Health service administration* / Patient care management
    - *Health care / Health service administration* / Quality of care
    - *Health care / Health care quality, access and evaluation* / Delivery of health care
    - *Health care / Health care quality, access and evaluation* / Health services research
    - *Health care / Health care quality, access and evaluation* / Health care quality assurance
    - *Health care / Health care quality, access and evaluation* / Quality of health care
- Sub-headings
    - ec (economics);
    - og (organization & administration);
    - st (standards);
    - sd (supply and distribution);
    - ut (utilization)

Appendix A.2

Screening criteria systematic literature review Chapter 2

This appendix contains an overview of all relevance and quality screening criteria that were used as part of the systematic literature review.

Criteria relevance screening:

Inclusion (I) and exclusion (E) criteria
1. Does the study aim at developing a business process redesign method or at reviewing multiple business process redesign methods? *(I)* a. Does the method aim at redesigning inter-departmental or inter-organizational order-fulfillment processes? *(I)* b. Is the method a holistic method? *(I)* i. Does the method aim at changing at least three different process aspects in terms of the BPR framework (Reijers and Limam Mansar 2005)? *(I)* ii. Does the method take into account the effects of redesigns on at least two different process performance dimensions in terms of the Devil's Quadrangle (Reijers and Limam Mansar 2005)? *(I)* c. Does the method support practitioners in generating process improvement ideas? *(I)* i. Does the method only aim at framing the process of interest? *(E)* ii. Does the method only aim at modeling or analyzing the AS-IS situation? *(E)* iii. Does the method only aim at evaluating different process alternatives? *(E)* iv. Does the method only aim at implementing a new process improvement idea? *(E)* d. Is the method customized for another domain than the healthcare domain? *(E)*

Table A.2.1. Overview relevance criteria related to first part of systematic literature review.

Inclusion (I) and exclusion (E) criteria
1. Does the study aim at identifying success factors of business process redesign initiatives? *(I)* a. Does the study focus on initiatives that aim at redesigning inter-departmental or inter-organizational order-fulfillment processes? *(I)* b. Does the study focus on initiatives that aim at holistic business process improvement? *(I)* i. Do the initiatives aim at changing at least three different process aspects in terms of the BPR framework (Reijers and Limam Mansar 2005)? *(I)* ii. Do the initiatives take into account the effects of redesigns on at least two different process performance dimensions in terms of the Devil's Quadrangle (Reijers and Limam Mansar 2005)? *(I)* c. Does the study focus on initiatives that aim at supporting practitioners in generating process improvement ideas? *(I)* iii. Do the initiatives only aim at framing the process of interest? *(E)* iv. Do the initiatives only aim at model\ing or analyzing the AS-IS situation? *(E)* v. Do the initiatives only aim at evaluating different process alternatives? *(E)* vi. Do the initiatives only aim at implementing a new process improvement idea? *(E)* d. Are the success factors actionable and formulated at the task level? *(I)* e. Does the study aim at identifying success factors that are specific for another domain than the healthcare domain? *(E)*

Table A.2.2. Overview relevance criteria related to second part of systematic literature review.

Criteria quality screening:

Inclusion (I) and exclusion (E) criteria
1. Is a clear statement of the research objective and scope available? *(I)* 2. Is the activity of generating process improvement ideas explained? *(I)* 3. Does a literature review or field study form the basis for the development / review of the business process redesign method(s)? *(I)*

Table A.2.3. Overview quality criteria related to first part of systematic literature review.

Inclusion (I) and exclusion (E) criteria
1. Is a clear statement of the research objective and scope available? *(I)* 2. Is a clear statement of the research methodology available? *(I)* 3. Are clear descriptions of success factors available? *(I)*

Table A.2.4. Overview quality criteria related to second part of systematic literature review.

Appendix A.3

Data extraction form systematic literature review Chapter 2

In this appendix, we present the data extraction form that was used to extract relevant data fragments from all studies included in the systematic literature review.

Method element		
Data extraction element	**Definition**	**Tag name**
1. Aim	The objective of the method activity	Method.Aim
2. Actors	The role who executes the method activity	Method.Actors
3. Input	The information that is collected prior to the method activity	Method.Input
4. Output	The artifacts that are the results of the method activity	Method.Output
5. Technique	Prescription of how to execute the method activity	Method.Technique
6. Tool	A software package that is able to support the method activity	Method.Tool
Research procedure element		
Data extraction element	**Definition**	**Tag name**
1. Type of source	Type of source (Journal paper / Conference paper / Book chapter / Technical report)	-
2. Type of study	Type of study (Method development study / Method review study / Success factor study)	-
3. Label research area	The business process redesign related label that is used in the study (e.g. clinical pathways, lean, six sigma)	-
4. Study design	The study design that is used (e.g. literature review, lab experiment, field study)	Study.Design
5. Data collection techniques	The way data is collected (e.g. interviews, questionnaires, observations, document analysis)	Study.Collection
6. Data analysis techniques	The way data is analyzed (e.g. structured equation modeling)	Study.Analysis

Table A.3.1. Data extraction form of systematic literature review.

Appendix A.4

Quantitative overview method options Chapter 2

This appendix contains an overview of the number of studies mentioning a certain method option of the methodological framework.

Decision area	*Category*	*Sub-category*	*Method option*	*No. of studies part 1*	*No. of studies part 2*	*No. of studies part 1 + 2*
Aim	Performance dimensions		Revenue	6	7	13
			Costs	31	12	43
			Time	26	11	37
		Quality	Quality (unspecified)	17	4	21
			External quality	22	11	33
			Internal quality	4	7	11
			Flexibility	13	1	14
	Degree of improvement		Radical improvement	6	3	9
			Incremental improvement	6	3	9
Actors	Daily involved		Process actor	23	10	33
			Management	15	7	22
	Advising	Supporting staff	BPR specialist	4	1	5
			Finance specialist	1	1	2
			HR specialist	0	1	1
			IS specialist	5	5	10
			Marketing specialist	1	1	2
			Customer	4	7	11
			Supplier	1	5	6
			External consultant	14	7	21
			Peer	0	1	1

Table A.4.1. Quantitative overview methods options (Aim, Actors).

Decision area	*Category*	*Sub-category*	*Method option*	*No. of studies part 1*	*No. of studies part 2*	*No. of studies part 1 + 2*
Input	Redesign requirements		Process output goals	27	5	32
			Stakeholder / patient needs	11	5	16
	Redesign limitations		Constraints	2	0	2
			Risks	2	0	2
	AS-IS process specification		Textual process description	8	0	8
			Process model	28	6	34
			Simulation model	3	1	4
	Process weaknesses		Process output measures	14	2	16
			Process measures	6	0	6
			Different opinions regarding AS-IS process specification	1	0	1
			Problem investigation	20	6	26
			Culture scan	1	0	1
	Redesign catalysts		Medical guidelines / key interventions	0	2	2
			Previous solutions	3	0	3
			Benchmark process insights	3	2	5
			Benchmark process models	1	0	1
			Technology developments	4	2	6
			Industry value net	1	0	1
Output	TO-BE specifications		TO-BE service concepts	3	0	3
		TO-BE process specification	Summary redesign proposals	19	0	19
			Textual process descriptions	8	0	8
			Process models	26	1	27
			Simulation models	11	1	12
			TO-BE exception handlers	3	0	3
	TO-BE assessments		Impact analyses	17	0	17
			Force-field-analyses	3	0	3

Table A.4.2. Quantitative overview methods options (Input, Output).

Decision area	*Category*	*Sub-category*	*Method option*	*No. of studies part 1*	*No. of studies part 2*	*No. of studies part 1 + 2*
Technique	Unstructured		Brainstorming	15	1	16
			Out-of-the-box thinking	5	1	6
			Visioning	4	1	5
			Unspecified	16	0	16
	Semi-structured		Delphi	1	0	1
			Nominal group	10	0	10
			Multi-level design	3	0	3
			Grammar-based	4	0	4
	Structured		Rule-based	23	1	24
			Case-based	5	0	5
			Repository-based	9	0	9
Tool			Communication	9	2	11
			Voting	6	1	7
			Modeling	13	2	15
			Simulation	8	1	9
			Repository	19	2	21
			Specific	4	0	4

Table A.4.3. Quantitative overview methods options (Technique, Tool).

Appendix B.1

Boolean expression cross-case analysis Chapter 3

In this appendix, we explain the Boolean expression of the cross-case analysis that was used for searching potentially relevant studies.

The Boolean expression was based on the research objective and derived from the thesaurus terms of three electronic databases, i.e. ABI/Inform, INSPEC, and Medline. The elements “redesign”, “process”, and “hospital” were derived from the research objective and related scoping decisions. In line with systematic literature review protocol discussed in Appendix A.1, a structured scan of the thesaurus trees of all electronic databases was performed to discover related thesaurus terms for all these elements. After obtaining the thesaurus terms, additional synonyms and acronyms were identified by means of a general thesaurus, acronym library, and trial searches. Finally, advanced search options like Boolean operators and truncation symbols were used to construct the free text search term. This procedure resulted in a Boolean expression consisting of four parts:

(([process] AND [redesign]) OR [process redesign]) AND [hospital]

In order to enable an efficient but comprehensive search, it was decided to search for the last part of the Boolean expression in title, abstract, and key words and to search for the first three parts in the title. Each part in the above Boolean expression surrounded by the ([ ]) symbol is itself a Boolean expression consisting of synonyms and abbreviations. For each part, the complete Boolean expression is shown in Table B.1.1.

Part	Complete Boolean expression
Process	business model: OR care ADJ3 continuit: OR care ADJ3 continuum: OR case management OR chain: OR delivery system: OR network: OR operation: OR order fulfil: OR order processing OR organi#ational model: OR pathway: OR patientflow: OR patient flow OR process OR processes OR product: line: OR service: OR workflow: OR work flow:
Redesign	chang: OR CI OR CQI OR CQM OR design: OR develop: OR engineer: OR improv: OR innovat: OR invent OR inventi: OR optim: OR Quality Management OR redesign: OR reengineer: OR re-engineer: OR reform: OR reorgani: OR restructur: OR streamlin: OR total quality OR TQM
Process redesign	BPR OR clinical ADJ2 path: OR critical ADJ2 path: OR disease management OR integrated delivery OR integrated ADJ2 path: OR kaizen OR lean OR patient ADJ2 centered ADJ2 care OR patient ADJ2 focused ADJ2 care OR six sigma
Hospital	clinic OR clinics OR care cent: OR care facilit: OR care network: OR health ADJ2 cent: OR health ADJ2 facilit: OR health ADJ2 network: OR medical ADJ2 cent: OR medical ADJ2 facilit: OR medical ADJ2 network: OR health maintenance organi#ation: OR HMO OR hospital OR hospitals OR infirmar: OR PHO OR surgical cent: OR surgicent: OR treatment cent:

Table B.1.1. Overview Boolean expressions of cross-case analysis. The Boolean expressions in this table are used in the INSPEC and Medline database. In the ABI/Inform database slightly different truncation symbols are used; PHO = Physician Hospital Organization and HMO = Health Maintenance Organization.

The free text search was complemented with the use of database specific headings. Specifically, we complemented the free text search with the use of high-level subject headings and classification codes in INSPEC and Mesh headings and sub-headings in Medline. Headings were not used in ABI/Inform due to the absence of a clear hierarchical tree structure of headings. Regarding the other electronic databases, the selection of headings was on the safe side of inclusiveness. The detailed search filters of the three electronic databases, including the selected headings, are shown in below.

General:

Date electronic searches:
13/10/2011

ABI/Inform:

Filter settings advanced search:
- Database: ABI/INFORM GLOBAL
- Data range: after this data: 01/01/2005
- Limit results to: Scholarly journal, including peer-reviewed
- Exclude: Book reviews; Dissertations; Newspapers

INSPEC:

Filter settings multi-field search:
- English language
- Abstract
- Publication year: 2005 - Current
- Publication types: Conference paper; Conference Proceedings; Journal paper
- Subject headings:
    - Systems analysis (not exploded)
        - Systems re-engineering
    - Business process re-engineering
    - Customer services
    - Management of change
    - Organizational aspects (not exploded)
    - Production management (not exploded)
        - Process planning
        - Logistics
    - Quality management (not exploded)
        - Total quality management
        - Continuous improvement
        - Six sigma (quality)
        - Innovation management
    - Supply chain management (not exploded)
    - Administrative data processing
    - Operations research (not exploded)
    - Order processing
    - Management science (not exploded)

    - Health care
    - Patient care
    - Systems engineering
    - Production engineering
    - Industrial engineering
    - Value engineering
    - Process design
    - Optimal systems
    - Constraint theory
    - Constraint handling
    - Lean production
    - Benchmark testing
- Classification codes:
    - Systems theory applications in economics and business
    - Systems theory applications in industry
    - Business and administration (not exploded)
        - Office automation
        - Public administration
        - Medical administration
        - Manufacturing and industrial administration
        - Administration of other service industries
    - Business and professional IT applications
    - Health care applications of IT
    - Industrial and manufacturing applications of IT
    - General topics in manufacturing and production engineering (not exploded):
        - Management and business
        - Organizational aspects
        - Management issues
        - Information technology applications (not exploded)
            - Industrial applications of IT
            - Business applications of IT
    - Production management
    - Research and development
    - Design
    - Manufacturing systems
    - System theory applications

Medline:

Filter settings multi-field search:
- English language
- Abstract
- Publication year: 2005 - Current
- Mesh headings:
    - *Information sciences / Information science* / Systems analysis
    - *Health care / Health care facilities, manpower and services* / Capacity building

  - *Health care / Health care facilities, manpower and services* / Health facilities
  - *Health care / Health care facilities, manpower and services* / Health services
  - *Health care / Health care economics and organizations* / Health planning
  - *Health care / Health service administration* / Organization and administration
  - *Health care / Health service administration* / Patient care management
  - *Health care / Health service administration* / Quality of care
  - *Health care / Health care quality, access and evaluation* / Delivery of health care
  - *Health care / Health care quality, access and evaluation* / Health services research
  - *Health care / Health care quality, access and evaluation* / Health care quality assurance
  - *Health care / Health care quality, access and evaluation* / Quality of health care
- Sub-headings
  - ec (economics);
  - og (organization & administration);
  - st (standards);
  - sd (supply and distribution);
  - ut (utilization)

Appendix B.2

Screening criteria cross-case analysis Chapter 3

In this appendix, we provide an overview of all relevance and quality screening criteria that were used as part of the cross-case analysis.

Inclusion (I) and exclusion (E) criteria
1. Does the study report about the application and evaluation of a business process redesign method in a real-life context? *(I)* 2. Does the described initiative aim at redesigning an inter-departmental or inter-organizational process in a hospital environment? *(I)* 3. Does the described initiative aim at holistic business process improvement? *(I)* a. Does the described initiative aim at changing at least three different process elements in terms of the BPR framework (Reijers and Limam Mansar 2005? *(I)* b. Does the described initiative take into account the effects of redesigns on at least two different process performance dimensions in terms of the Devil's Quadrangle (Reijers and Limam Mansar 2005)? *(I)* 4. Does the described initiative aim at generating process improvement ideas *(I)* a. Does the described initiative only aim at framing the process of interest? *(E)* b. Does the described initiative only aim at modeling or analyzing the AS-IS situation? *(E)* c. Does the described initiative only aim at evaluating different process alternatives? *(E)* d. Does the described initiative only aim at implementing a new process design? *(E)*

Table B.2.1. Overview relevance criteria of cross-case analysis.

Inclusion (I) and exclusion (E) criteria
1. Is there a clear statement of the research objective and scope? *(I)* 2. Does the study provide a clear description of the process improvement ideas? *(I)* 3. Does the study provide a clear description of evaluated process outcomes? *(I)* 4. Does the study provide a clear description of the applied method that aims at generating process improvement ideas? *(I)* a. Does the description include information about the aim of the method? *(I)* b. Does the description include information about at least one of the other method elements? *(I)*

Table B.2.2. Overview quality criteria of cross-case analysis.

Appendix B.3

Data extraction form cross-case analysis Chapter 3

This appendix contains the data extraction form that was used to extract relevant data fragments from all studies included in the cross-case analysis.

Method element		
Data extraction element	**Definition**	**Tag name**
1. Aim	The objective of the method activity	Method.Aim
2. Actors	The role who executes the method activity	Method.Actors
3. Input	The information that is collected prior to the method activity	Method.Input
4. Output	The artifacts that are the result of the method activity	Method.Output
5. Technique	Prescription of how to execute the method activity	Method.Technique
6. Tool	A software package that is able to support the method activity	Method.Tool
Case study characteristic		
Data extraction element	**Definition**	**Tag name**
1. Type of source	Type of source (Journal paper / Conference paper / Book chapter / Technical report) of the study	-
2. Label research area	The business process redesign related label that is used in the study (e.g. clinical pathways, lean, six sigma)	-
3. Country	The country where the business process redesign initiative took place	-
4. Setting	The setting in which the business process redesign initiative took place (e.g. hospital, interorganizational (GP - hospital - nursing home)	-
5. Patient group	The patient group that was targeted by the business process redesign initiative	-
6. Annual patient volume	The annual patient volume of the patient group that was the subject of investigation	-

Table B.3.1. Data extraction form of cross-case analysis.

Appendix B.4

Screening criteria field study Chapter 3

In this appendix, we explain the screening criteria that were used to select consultancy companies for the field study.

The starting point for the screening of consultancy companies was the Company.info database. This database contains information about more than 2 million organizations active in the Netherlands. Among others, this database includes a brief profile description and several key figures (e.g. yearly turnover) for each company. The investigation of the Company.info database contained a three-stage screening procedure: (1) a selection of relevant company categories, (2) a screening of company descriptions in the database, and (3) a screening of company websites.

1. Selection of relevant company categories

The database distinguishes several company categories. We decided to limit our search to three categories that might include potentially relevant consultancy firms: *Activities of head offices and management consultancy activities*, *Management consultancy activities*, and *Technical design and consultancy for process engineering*.

2. Screening of company descriptions in database

The profile descriptions and key figures of all companies belonging to the three categories mentioned above were screened to eliminate irrelevant companies. The inclusion and exclusion criteria in Table B.4.1 were used during this screening.

Inclusion (I) and Exclusion (E) criteria
1. Is the company economically active and does it have a turnover of more than 1 million euro? *(I)** 2. Is the company specialized in an area that is not related to the redesign of business processes (e.g. construction engineering)? *(E)***

Table B.4.1. Overview screening criteria stage 2.

* It is assumed that companies that do not fulfill this criterion have difficulty in sharing numerous experiences regarding the application of business process redesign methods.
** Companies offering general management consultancy services that did not refer to the redesign of business processes in their company description were still included at this stage of the screening procedure.

3. Screening of company websites

The websites of all companies that passed the second stage of the screening procedure were screened in detail. The inclusion and exclusion criteria in Table B.4.2 were used during this screening.

Inclusion (I) and Exclusion (E) criteria
1. Is the company active in redesigning business processes? *(I)**   2. Is the company active in the healthcare domain and one other application domain? *(I)*

Table B.4.2. Overview screening criteria stage 3.

* The website should refer to at least one service that is related to the redesign of business processes, such as "Business Process Management", "Lean", "Operational Excellence", "Six Sigma" and "Supply Chain Management".

After the three-stage screening procedure of the Company.info database, all 2011 magazines of a popular Dutch Business Process Management (BPM) periodical and its related website were reviewed to further establish that potentially relevant consultancy firms did not remain unidentified. After identification of additional, potentially relevant companies by screening this periodical, the websites of these companies were screened to evaluate all criteria in Table B.4.1. and Table B.4.2.

Appendix B.5

Methodological framework
Chapter 3

In this appendix, the final methodological framework is presented. More specifically, we provide an overview of all method options identified and include definitions for all these options in Table B.5.1 - B.5.6. Figure B.5.1 provides a graphical, high-level summary of the methodological framework.

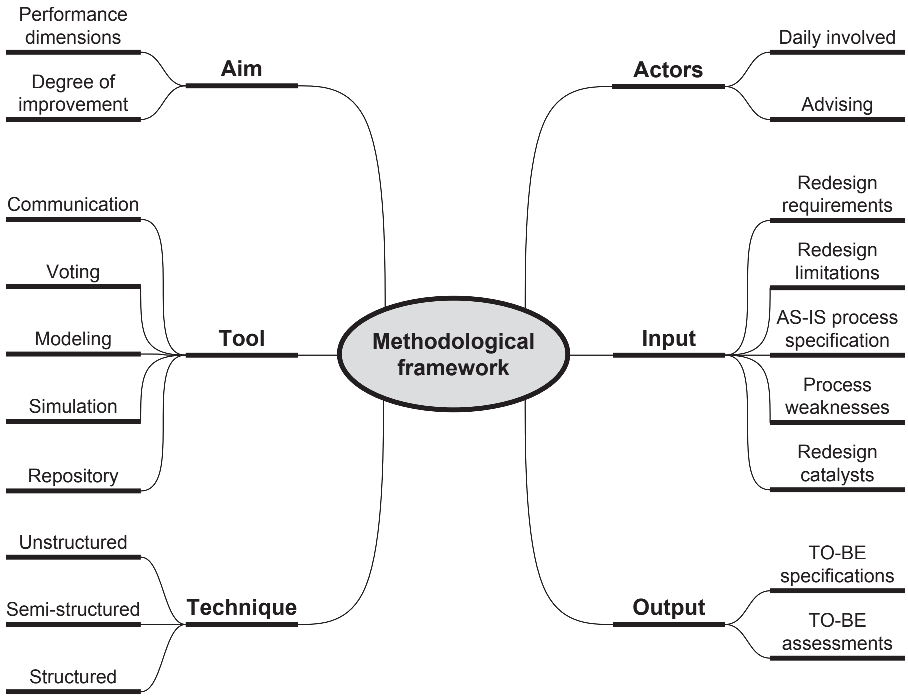

Figure B.5.1. Graphical summary methodological framework.

Aim

Method option	*Definition*
Performance dimensions (delineating the kind of performance measures that need improvement):	
Revenue	The income that is received from the sales of goods or services that are created by the process.
Costs	The value of money that has been used to produce goods or services that are created by the process.
Time	A measure of durations of events or intervals between them.
External quality	The quality of products or services as perceived by customers.
Internal quality	The quality of work as perceived by process actors.
Flexibility	The ability of the process to react to changes (Jansen-Vullers et al 2008).
Compliance to legal rules	Adherence to laws, regulations, and other requirements set by government or related regulatory institutes.
Degree of improvement (addressing the kind of improvement that is needed):	
Radical improvement	The aim is to achieve dramatic improvement gains by often challenging the organizational framework and applying new technology (Glykas and Valiris 1999).
Incremental improvement	The aim is to make some small changes to an existing process by typically eliminating non-value-added activities (Glykas and Valiris 1999).

Table B.5.1. Aim related definitions.

Actors

Method option	*Definition*
Daily involved (involved in either executing tasks within the process under study or managing the process):	
Process actor	Actor who is involved in executing tasks within the process.
Management	Actor who is involved in managing the process.
Advising (not being responsible for the process under study, but able to contribute to the development of process alternatives due to expertise or experience):	
BPR specialist	Supporting staff specialist who has specific expertise in redesigning business processes.
Finance specialist	Supporting staff specialist who is knowledgeable about financial issues.
HR specialist	Supporting staff specialist who is knowledgeable about human resource management.
IS specialist	Supporting staff specialist who has specific expertise in designing information systems.
Marketing specialist	Supporting staff specialist who has specific expertise in communicating the value of a product or service to customers.
Quality assurance specialist	Supporting staff specialist who has specific expertise in ensuring that legal and other quality-related requirements are met by the services provided by an organization.
Customer / patient	Recipient of the products or services that are provided by the process.
Supplier	Actor who supplies goods or services that are used by the process.
External consultant	Actor who is employed externally (not a member of the firms where the process actors are employed) and provides professional advice on a temporary basis.
Employer representative	Representative of an employer’s organisation.
Health insurance commissioner	Representative of a healthcare insurance company.
Peer	Actor who is employed internally or externally and is actively involved in a non-competing similar process.

Table B.5.2. Actors related definitions.

Input

Method option	*Definition*
Redesign requirements (delineating the redesign objectives that need to be achieved):	
Process output goals	Desired end results of the redesign project in terms of process performance dimensions, e.g. the average access time of coronary artery bypass patients needs to be reduced with 60%.
Stakeholder / patient needs	Requirements that need to be fulfilled by the process according to patients or other process stakeholders.
Legislation	Laws, regulations, and other requirements set by government or related regulatory institutes.
Redesign limitations (outlining the factors that restrict the solution space):	
Constraints	Restrictions that delineate the kind of process alternatives that are not going to be considered.
Risks	Factors that challenge the redesign of the process and might restrict the kind of process alternatives that are going to be considered (Limam Mansar et al. 2009).
AS-IS process specification (providing a description of the current process):	
Textual process description	Textual description of the AS-IS process.
Process model	Model that provides a graphical representation of the AS-IS process (Kettinger et al. 1997).
Simulation model	Model that allows for the dynamic modeling of the AS-IS process (Kettinger et al. 1997).
Physical lay-out	Physical arrangement of the AS-IS process.
Process weaknesses (identifying redesign priorities):	
Process output measures	Measures that are related to the process performance dimensions.
Process measures	Measures that provide a global view on the characteristics of the process, such as the degree of automation or parallelism (Netjes et al. 2008).
Different opinions regarding AS-IS process specification	Points of disagreement about how the AS-IS process works. Typically, these points of disagreement become apparent during process mapping activities (Bitner et al. 2008).
Problem investigation	Investigation which offers information regarding problems as perceived by the different process stakeholders.
Culture scan	Assessment of the shared values and beliefs of process stakeholders (Kettinger et al.1997).
Redesign catalysts (providing inspiration for the creation of effective process alternatives):	
Medical guidelines / key interventions	Documents with the aim of guiding decisions and criteria regarding diagnosis, management, and treatment in specific areas of healthcare. Typically, they are based on an examination of current evidence in the paradigm of evidence-based management (Vanhaecht et al. 2009).
Previous solutions	Solutions that have been suggested for problems that are related to the problems associated with the process under study (Chai et al. 2005; Lin and Su 2007; Su et al. 2008).
Benchmark process insights	Insights gained from comparing one's process with a similar process (Rohleder and Silver 1997; Talib and Rahman 2010).
Benchmark process models	Process models of a similar process (Bitner et al. 2008).
Technology developments	Insights gained from technology observing research (Hsiao and Yang 2010).
Industry value net	Overview of suitable partners with which the process under study could be integrated (Hsiao and Yang 2010).

Table B.5.3. Input related definitions.

Output

Method option	*Definition*
TO-BE specifications (providing descriptions of process improvement ideas):	
TO-BE service concepts	Concepts that provide a description of the benefits that the process is expected to offer to the customers and determine the value proposition in the broader context of the value network within which it is embedded. As such, TO-BE service concepts are able to guide the design of TO-BE process specifications (Patrício et al. 2011).
Summary redesign proposals	Summary that provides a brief description of process improvement ideas, i.e. changes with regard to the AS-IS process that are worth further investigation.
Textual process descriptions	Textual descriptions of TO-BE processes.
Process models	Models that provide graphical representation s of TO-BE processes (Kettinger et al. 1997).
Simulation models	Models that allow for the dynamic modeling of TO-BE processes and support practitioners in validating and evaluating process alternatives (Kettinger et al. 1997).
Physical lay-outs	Physical arrangements of TO-BE processes
Check-lists	Organized instruments that outline criteria of consideration for TO-BE processes. It functions as a support resource by delineating and categorizing items as a list -a format that simplifies conceptualization and recall of information (Hales et al. 2008).
TO-BE exception handlers	Handlers that describe ways to anticipate, avoid, detect, and resolve process exceptions (Klein and Dellarocas 2003).
TO-BE assessments (including preliminary evaluations of process alternatives) :	
Impact analyses	Analyses that provide insights into the potential performance improvement impact and feasibility of process improvement ideas (Jansen-Vullers and Reijers 2005).
Force-field-analyses	Analyses that provide insights into the forces that either drive or restrain the implementation of process alternatives (Corbitt and Wright 1997; Corbitt et al. 2000; Kettinger et al. 1997).

Table B.5.4. Output related definitions.

Technique

Method option	*Definition*
Unstructured (not containing a detailed procedure that specifies how to move from current process insights (as-is) to concrete improvement ideas (to-be) and not providing guidance regarding the kind of process alternatives that need to be considered):	
Brainstorming	Creativity technique that provides room for spontaneous generation of ideas by redesign participants, where creative thinking is stimulated through a process of adding on the other's concepts (Dennis et al. 2003; Kettinger et al. 1997).
Out-of-the-box thinking	Creativity technique that stimulates redesign participants to stretch redesign goals and reconsider assumptions underlying current process execution (Dennis et al. 2003; Kettinger et al. 1997).
Visioning	Creativity technique that encourages redesign participants to develop images of possible future processes by identifying and progressively breaking sacred cow assumptions or unsubstantiated constraints (Dennis et al. 2003; Kettinger et al. 1997).
Semi-structured (offering a work procedure that specifies how to move from current process insights (as-is) to concrete improvement ideas (to-be), but lacking any guidance regarding the kind of process alternatives that need to be considered):	
Delphi	Technique that distributes a sequence of anonymous questionnaires to redesign participants to successively refine their opinions and finally reach consensus (Kettinger et al. 1997).
Nominal group	Technique that offers a procedure for reaching group consensus through anonymous idea generation by individual redesign participants, followed by discussion and voting (Kettinger et al. 1997).
Multi-level design	Technique that starts with designing the to-be situation at a relatively high level of abstraction, i.e. the to-be service concept. After completion, two lower levels of abstraction, which together specify the to-be process, are successively considered (Patrício et al. 2011).
Grammar-based	Technique that captures the grammar underlying a business process and makes use of lexicon and rewrite rules to systematically explore process alternatives (Lee et al. 2008; Lee and Pentland 2000).
Structured (offering a work procedure that specifies how to move from current process insights (as-is) to concrete improvement ideas (to-be) and including guidance regarding the kind of process alternatives that need to be considered):	
Rule-based	Technique that makes use of generic process redesign rules that have accumulated in literature or practice to develop process alternatives (Chai et al. 2005; Nissen 2000; Reijers and Limam Mansar 2005). The premise of these techniques is that specific process problems can be translated to generic process problems, for which generic process redesign rules can offer generic process solutions (Jansen-Vullers and Reijers 2005; Lin and Su 2007; Nissen 2000). An example of a generic process redesign rule is the parallelism rule, which states that redesign participants should consider executing tasks in parallel instead of executing them sequentially (Reijers and Limam Mansar 2005). As a final step, the generic process solutions have to be translated to specific process solutions (Jansen-Vullers and Reijers 2005; Lin and Su 2007; Nissen 2000).
Case-based	Technique that enables an efficient identification of earlier business process redesign projects. These projects offer guidance regarding the process alternatives that can be considered (Limam Mansar et al. 2003). These techniques make use of libraries of well-document previous business process redesign projects (Limam Mansar et al. 2009; Limam Mansar et al. 2003; Nissen 2000).
Repository-based	Technique that makes use of the notions of process specializations, coordination mechanisms and process exception handlers to systematically generate process alternatives on the basis of an identified list of core activities of the process under study and a repository (Bernstein et al. 1999; Klein and Petti 2006; Malone et al. 1999; Margherita et al. 2007). The repository that is used as a basis includes and organizes numerous specifications of existing processes (Bernstein et al. 1999; Klein and Petti 2006; Malone et al. 1999; Margherita et al. 2007).

Table B.5.5. Technique related definitions.

Tool

Communication	Functionality that enables large groups to communicate face-to-face or distributed in a computer-mediated electronic environment. Typically, this environment allows for parallel and anonymous input (Albano et al. 2001; Corbitt et al. 2000; Piirainen et al. 2009).
Voting	Functionality that allows participants to rate different process alternatives (Corbitt and Wright 1997; Mouro et al. 1999).
Modeling	Functionality that supports practitioners in creating graphical representations of process alternatives (Albano et al. 2001; Netjes et al. 2008; Thong et al. 2003).
Simulation	Functionality that allows dynamic modelling of business processes and supports practitioners in validating and evaluating process alternatives (Kettinger et al. 1997; Nissen 2000).
Repository	Functionality that provides support for the storage and retrieval of descriptions of process alternatives and related discussions (Albano et al. 2001; Mouro et al. 1999; Valiris and Glykas 1999).
Specific	Functionality that provides support for a specific technique and does not provide general-purpose functionality.

Table B.5.6. Tool related definitions.

Appendix C.1

Protocol Delphi procedure Chapter 4

In this appendix, we outline the Delphi procedure that was used to compare and integrate the BPR best practices and TRIZ innovation principles.

Team composition

The Delphi procedure team consisted of one *moderator* and four *panel experts*. The *moderator* was responsible for the development of the Delphi procedure, the coordination of all administrative activities during the execution of the procedure, and chairing all discussion meetings with the expert panel. The *panel experts* were involved in executing the different steps of the Delphi procedure. All panel experts had followed several master courses with regard to Business Process Management and had been involved in at least two business process redesign projects.

Procedure details

The Delphi procedure consisted of five steps:

1. Obtain a full understanding of the 29 BPR best practices and 40 TRIZ innovation principles
2. Consider the atomicity of the 29 BPR best practices
3. Identify relationships between the different groups of principles
4. Identify new principles and new related categories
5. Identify additional enhancements

Each step, except the first step, contained two individual rounds and one consensus round. During the first individual round, each panel expert had to independently execute the step as explained in a detailed instruction document. After the first individual round, the moderator collected the results and provided an anonymous overview of the panel experts' results. During the second individual round, each panel expert was encouraged to revise her / his earlier answers in the light of the replies of other panel experts. After the second individual round, the moderator provided again an anonymous overview of the panel experts' results. This overview was input for the consensus round. During this round, a meeting was organized with all panel experts to reach consensus in a face-to-face meeting chaired by the moderator.

Each step of the Delphi procedure is explained in more detail below.

Step 1: Obtain a full understanding of the 29 BPR best practices and 40 TRIZ innovation principles

As a first step, the 29 BPR best practices and related categories, and the 40 TRIZ innovation principles were studied in detail by the panel experts. In the next Delphi procedure steps, the 40 TRIZ innovation principles were compared with 29 BPR best practices in a structured manner. We often use the term "principles" to refer to both "BPR best practices" and "TRIZ innovation principles" in the remainder of this appendix.

Step 2: Consider the atomicity of the 29 BPR best practices

Several BPR best practices include dichotomous scenarios (e.g.specialist-generalist: consider to make resources *more specialized* or *more generalist*). In order to facilitate an easy comparison between TRIZ innovation principles and BPR best practices, it was decided to identify the BPR best practices with dichotomous scenarios and to split these practices in two atomic principles (e.g. specialist: consider to make resources *more specialized*; generalist: consider to make resources *more generalist*). Table C.1.1 was used by the panel experts to document their results.

BPR best practice (original)	**BPR best practice (variant 1)**	**BPR best practice definition (variant 1)**	**BPR best practice (variant 2)**	**BPR best practice definition (variant 2)**

Table C.1.1. Documentation step 2.

Step 3: Identify relationships between the different groups of principles

After considering the atomicity of the BPR best practices, relationships between the TRIZ innovation principles and (atomic) BPR best practices were identified. More specifically, each TRIZ innovation principle was compared with the set of BPR best practices and the following relationships were considered successively:

- **Association** – An "is like" association relationship implies that the TRIZ innovation principle has a similar meaning as one of the BPR best practices.
- **Generalization** – A generalization relationship indicates that one principle (child) is considered to be a specialized form of another principle (parent). Both directions are possible in our case: either a TRIZ innovation principle can be a child of a BPR best practice, or a BPR best practice can be a child of a TRIZ innovation principle.
- **None of the above relationships**

The following rules were taken into account when identifying relationships between principles:

- It is assumed that each TRIZ innovation principle has an "association" relationship with at maximum one BPR best practice.
- Only in case no "association" relationship can be identified, a "generalization" relationship was considered.
- For each identified relationship, the reasoning behind the choice for a certain relationship had to be explicitly stated by each panel expert.

The results of this step were documented by the panel experts in Table C.1.2.

TRIZ innovation principle	BPR best practice	BPR best practice category	Relationship	Comments

Table C.1.2. Documentation step 3.

Step 4: Identify new principles and related new categories

After the identification of the relationships, we investigated possibilities for adding new TRIZ-related principles and related new categories to the set of BPR best practices. More specifically, each TRIZ innovation principle for which neither an “association” nor a “generalization” relationship could be identified in the previous step was assessed in detail. This assessment was aimed at identifying TRIZ innovation principles that could be translated to a new principle that was not covered by the existing set of BPR best practices. Here, translation refers to aligning the wording of the name and/or definition of the principle with common *process redesign* terminology. The following possibilities were considered successively:

- A TRIZ innovation principle can be translated to a new principle and can be added to an existing BPR best practice category.
- A TRIZ innovation principle can be translated to a new principle, but it cannot be added to an existing BPR best practice category. In this case, a new category should be defined in addition.
- A TRIZ innovation principle cannot be translated to a new principle (i.e. it is related to a characteristic that is specific for products, such a thermal expansion).

The following rules were taken into account while making the above decision:

- For each TRIZ innovation principle that can be translated to a new principle, the reasoning behind this decision had to be explicitly stated by each panel expert (in the form of illustrative application examples).
- For each TRIZ innovation principle that can be translated to a new principle, a decision had to made whether the name and/or definition of the principle needed adjustment in order to align the terminology with common process redesign terminology.
- When creating new categories, one point of concern is whether several principles can be added to the same new category. Preferably, a category should be defined such that it is broad enough to capture multiple principles, but specific enough to be meaningful.

The results of this step were documented by the panel experts in Table C.1.3 and C.1.4.

TRIZ innovation principle	TRIZ innovation principle (renamed)	TRIZ innovation principle definition (renamed)	Existing / new category	Comments

Table C.1.3. Documentation step 4 (new principles).

New category	New category description

Table C.1.4. Documentation step 4 (new categories).

Step 5: Identify additional enhancements

After the identification of new principles and new categories, it was decided whether there was added value in adding a TRIZ innovation principle that was in a "generalization" relationship with a BPR best practice to the set of principles. In case of an addition, a decision was made whether keeping the related child or parent BPR best practice in the existing set of principles was valuable or not. In addition, the panel experts were asked to review whether principles within a certain category could be copied (with a slightly adapted name and / or definition) to another (new) category. Categories are describing process elements which can be addressed during a redesign project and it might be the case that a certain principle is relevant in more than one category.

In line with previous steps, the reasoning behind the decisions made had to be explicitly stated by the panel experts. Table C.1.5 and C.1.6 were used to document the results of this step.

TRIZ innovation principle	Relationship	BPR best practice	Category	Addition / substitution	TRIZ innovation principle (renamed)	TRIZ innovation principle definition (renamed)	Comments

Table C.1.5. Documentation step 5 (added / substituted principles).

TRIZ innovation principle (original)	TRIZ innovation principle (renamed)	Relation-ship	BPR best practice	Current category	New category	Principle (renamed in new category)	Principle definition (renamed in new category)	Com-ments

Table C.1.6. Documentation step 5 (principles copied to other categories).

Appendix C.2

Detailed overview of RePro principles Chapter 4

In this appendix, we provide the total list of RePro principles. Each RePro principle includes a name, a definition, an explanation, and an application example.

Level 1: Service concept

A. Customers

The principles in the *customers* category focus on improving contacts with customers.

1. Control relocation
'Move controls towards the customers (patients)'

By moving checks and other operations that are part of a process to the customer / patient, costs can be reduced and customer satisfaction might increase. A disadvantage of this solution is a higher probability of fraud.

Example:
Ask the patient, instead of the nurse, to pick up the drugs by the hospital pharmacy.

2. Contact reduction
'Reduce the number of contacts with customers (patients) and third parties'

The exchange of information with a customer / patient or third party is always time-consuming. Also, each contact introduces the possibility of intruding an error. Reducing the number of contacts may therefore decrease throughput time and boost quality. Note that it is not always necessary to skip certain information exchanges, but that it is possible to combine them with limited extra costs. A disadvantage of a smaller number of contacts might be the loss of essential information, which is a quality issue. Combining contacts may also result in the delivery or receipt of too much data.

Example:
Combine the hospital visit "recording of the heart activity (ECG)" and the hospital visit "cycling test". In the new situation, one hospital visit takes place in which both diagnostic tests are performed successively during one session.

3. Integration

'Consider the integration with a process of the customer (patient) or a supplier'

This principle is based on the supply-chain concept. An improved collaboration between the transaction partners (by performing intermediate reviews) enables possibilities for reducing costs and throughput times. The drawback of integration is that mutual dependence grows and, therefore, flexibility may decrease.

<u>Example:</u>
The treatment plan of an oncology patient is determined by the internist in a discussion session with the patient's general practitioner.

B. External environment

The principles in the *external environment* category try to improve upon the collaboration and communication with third parties.

4. Trusted party

'Instead of determining information oneself, use results of a trusted party'

Some decisions or assessments that are made within processes are not specific for the process these are part of. Other parties may have determined the same information in another context. Obviously, by making use of the information of a trusted party costs and throughput times can be reduced. On the other hand, the quality of the process becomes dependent upon the quality of some other party's work. Some coordination effort with trusted parties is also likely to be required, which diminishes flexibility.

<u>Example:</u>
Trust the 24-hours blood pressure monitoring data as provided by a general practitioner, instead of re-executing the monitoring as part of the hospital diagnosis trajectory.

5. Outsourcing

'Consider outsourcing a process as a whole or parts of it'

Another party may be more efficient in performing the same work. The obvious aim of outsourcing work is to reduce costs. A drawback may be that quality decreases. Outsourcing also requires more coordination efforts and will make the process more complex. Note that this principle differs from the "4. Trusted party" principle. When outsourcing, a task is executed at run time by another party. The "4. Trusted party" principle allows for the use of a result in the (recent) past.

<u>Example:</u>
Outsource the assessment of imaging images to a specialized center in India.

6. Interfacing
'*Consider a standardized interface with customers (patients) and partners'*

The idea behind this principle is that a standardized interface will diminish the probability of mistakes, incomplete applications, and unintelligible communications. Consequently, a standardized interface may result in less errors, faster processing, and less rework.

Example:
Invite patients to provide drug related information through a standardized interface.

Level 2: Main process design

C. Tasks

The principles in the *tasks* category focus on the tasks that are part of the process.

7. Order types
'Determine whether tasks are related to the same type of order (patient group) and, if necessary, distinguish new processes'

Ignoring that several parts of a process are not specific for certain type of orders / patient groups negatively affects the efficiency of the process. Applying this principle may result in faster processing times and less costs. Yet, it may also result in more coordination problems between the different processes (quality) and less possibilities for rearranging the process as a whole (flexibility).

Example:
Distinguish between the perioperative process (everything happening just before, during and just after surgery) of children and adults.

8. Task elimination

'Eliminate unnecessary tasks from the process'

Several tasks within a process do not provide value from a customer's / patient's point of view, such as control tasks and redundant tasks. The aim of this principle is to increase the speed of processing and reduce the costs of handling an order. An important drawback may be that the quality of the service deteriorates.

Example:
Stop providing paper-based, drug-related forms when all patients use a digital interface.

9. Prior counteraction
'Add tasks to prevent the occurrence of an undesirable situation or to reduce its impact'

"Prevention is better than cure" is the premise of this principle. Certainly, costs are involved in adding tasks. This investment can be recouped by throughput time reduction, quality improvement, and/or cost reduction due to preventing an undesirable situation or reducing the impact of such an event.

Example:
Perform a rigorous pre-operative screening before a patient receives open-heart surgery.

10. Prior action
'Perform tasks before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process'

Performing tasks before they need to be executed or adding tasks to smooth the execution of remaining tasks in the process has similar advantages and disadvantages as the "9. Prior counteraction" principle. The difference between both principles is that the prior counteraction principle has a "prevention" focus, whereas the prior action principle has a "stimulation" focus.

Example:
Ask the patient with knee-related complaints to undress in the preparation room, while the diagnosis of another patient is still ongoing.

11. Triage
'Consider the division of a general task into two or more alternative tasks' or 'consider the integration of two or more alternative tasks into one general task'

When applying this principle in its first most popular form, it is possible to design tasks that are better aligned with the capabilities of resources and the characteristics of the orders / patients being processed. Distinguishing alternative tasks may improve quality and facilitate a better utilization of resources with obvious cost and time advantages. On the other hand, too much specialization can make processes become less flexible, less efficient, and cause monotonous work with repercussions for quality. Note that this principle is in some sense similar to the "7. Order types" principle. The main interpretation of the triage concept can be seen as a translation of the order type best practice on a task level.

Example:
Differentiate the provision of perioperative information for patients with and without diabetes.

12. Task composition
'Combine small tasks into composite tasks and divide large tasks into workable smaller tasks'

Combining tasks should result in the reduction of setup times, i.e. the time that is spent by a resource to become familiar with the specifics of an order / a patient. By executing a large task which used to consist of several smaller ones some positive effects may also be expected on the quality of the delivered work. On the other hand, making tasks too large may result in smaller run-time flexibility and lower quality as tasks become unworkable. Both effects are exactly countered by dividing tasks into smaller ones.

Example:
The composition of Magnatic Resonance Imaging (MRI) activities: positioning the patient and setting up the equipment are composed into one task executed by an assistant.

Level 3: Detailed process design

D. Task order and timing

The principles in the *tasks order and timing* category focus on the order in which tasks are executed and the more detailed timing of task execution.

13. Order-based work
'Consider removing batch-processing and periodic activities from the process'

Some disturbances in handling a single order are: (a) its piling up in a batch and (b) periodic activities, i.e. activities that are only executed at specific times. Getting rid of these constraints may significantly speed up the handling of individual orders / patients. On the other hand, efficiencies of scale can be reached by batch or periodic processing.

Example:
Do not discuss all oncology patient once a week during a multi-disciplinary meeting, but discuss every patient in a multi-disciplinary meeting immediately after arrival of all test results of the patient.

14. Periodic action
'Consider making an action periodic or changing the periodicity of an already recurrent action'

Executing activities with a certain periodicity can lead to efficiency of scales. However, this principle typically leads to an increase in throughput times. Note the contrast of the objective of this principle and the objective of the "13. Order-based work" principle.

Example:
Organize information sessions for oncology patients once a week instead of providing information during consultations with individual patients.

15. Shortcut
'Introduce process shortcut possibilities'

By introducing possibilities to skip process parts under certain conditions, e.g. extreme busy waiting rooms, throughput times can be reduced. Application of this principle might have negative consequences for the quality of the process.

Example:
Skip checking insurance data of patients at the emergency deparment when waiting time is long and perform these insurance checks afterwards.

16. Resequencing
'Move tasks to more appropriate places'

In existing processes, actual tasks orderings do not reveal the necessary dependencies between tasks. Sometimes it is better to postpone a task if it is not required for immediately following tasks, so that perhaps its execution may prove to become superfluous. This saves costs. Also, a task may be moved into the proximity of a similar task, in this way diminishing setup times.

Example:
Take blood from a patient before the consultation with the medical specialist instead of after the consultation, in order to enable a discussion of the lab results during the consultation.

17. Knock-out
'Order knock-outs in an increasing order of effort and in a decreasing order of termination probability'

A typical part of a process is the checking of various conditions that must be satisfied to deliver a positive end result. Any condition that is not met may lead to a termination of that part of the process: the knock-out. If there is freedom in choosing the order in which the various conditions are checked, the condition that has the most favorable ratio of expected knock-out probability versus the expected effort to check the condition should be pursued. This way of ordering checks yields on average the least costly process execution. There is no obvious drawback on this principle, although it may not always be possible to freely order these kinds of checks. Also, implementing this principle may result in a (part of a) process that takes a longer throughput time than a full parallel checking of all conditions. Note that the knock-out principle is a specific form of the "16. Resequencing" principle.

Example:
Perform the lab-test before executing the time-consuming CT-scan (assumption: termination probability of further diagnostics/treatment is equal for both tests).

18. Parallelism
'Consider whether tasks may be executed in parallel'

The obvious effect of putting (sequential) tasks in parallel is that the throughput time may be considerably reduced. A drawback of introducing more parallelism in a process that incorporates possibilities of knock-outs is that the costs of process execution may increase. Also, the management of processes with concurrent behavior can become more complex, which may introduce errors or restrict run-time adaptations.

Example:
Do not wait with cleaning the surgery room till the patient has left the surgery room, but execute these activities in parallel.

19. Exception
'Design processes for typical orders (patients) and isolate exceptional orders (patients) from normal flow'

Exceptions may seriously disturb normal operations. An exception will require workers to get acquainted with the specifics of the exception, although they may not be able to handle it. Setup times are then wasted. Isolating exceptions will make the handling of normal orders / patients more efficient. Isolating exceptions may possibly increase the overall performance as specific expertise can be build up by workers working on the exceptions. The price paid is that the process will become more complex, possibly decreasing its flexibility. Also, if no special knowledge is developed to handle the exceptions (which is costly) no major improvements are likely to occur.

Example:
Refer surgery patients with a Body Mass Index (BMI) > 40 to a specialized nurse.

E. Human resources

The principles in the *human resources* category are mainly concerned with the number and types of available human resources and the way they are allocated to tasks.

20. Order assignment
'Let workers perform as many steps as possible for single orders (patients)'

By using order assignment in the most extreme form, for each task execution the resource is selected from the ones capable of performing it who has worked on the order / for the patient before — if any. The obvious advantage of this principle is that this person will get acquainted with the case and will need less setup time. An additional benefit may be that the quality of service is increased. On the negative side, the flexibility of resource allocation is seriously reduced. An order / a patient may experience substantial queue time when the person to whom the order / patient is assigned is not available.

Example:
The nurse who is responsible for the execution of the intake of the patient is also responsible for executing all checks and discharging the patient.

21. Customer teams
'Consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of orders (patients)'

This principle is a variation on the "20. Order assignment" principle. Depending on its exact desired form, the customer team principle may be implemented by the order assignment principle. Also, a customer team may involve more workers with the same qualifications, in this way relaxing the strict requirements of the order assignment principle. Advantages and disadvantages are similar to those of the order assignment principle. In addition, working as a team may improve the attractiveness of the work.

Example:
Assign to each oncology patient, one surgeon, one internist, and nurses who will take care of the complete handling of the activities of the patient.

22. Case manager
'Appoint one person as responsible for the handling an order (a patient), the case manager'

The case manager is responsible for a specific order or patient, but he or she is not necessarily the (only) resource who will work on it. Contrary to the "20. Order assignment" principle the emphasis is on the management of the process and not on its execution. The most important aim of the principle is to improve upon the external quality of a process. The process will become more transparent from the viewpoint of a customer as the case manager provides a single point of contact. This positively affects customer satisfaction. It may also have a positive effect on the internal quality of the process, as someone is accountable for correcting mistakes. Obviously, the assignment of a case manager has financial consequences as capacity must be devoted to this job.

Example:
Assign to each oncology patient a nurse practitioner who is responsible for all activities that are performed for the patient.

23. Flexible assignment (HR)
'Assign human resources in such a way that maximal flexibility is preserved for the near future'

For example, if a task can be executed by either of two available resources, assign it to the most specialized resource. In this way, the possibilities to have the free, more generalist resource execute another task are maximal. The advantage of this principle is that the overall queue time is reduced: it is less probable that the execution of an order / a patient has to wait for the availability of a specific resource. Another advantage is that the workers with the highest specialization can be expected to take on most of the work, which may result in a higher quality. The disadvantages of this principle can be diverse. For example, work load may become unbalanced resulting in less job satisfaction. Also, possibilities for specialists to evolve into generalists are reduced.

Example:
Assign patients with knee-related problems to medical specialists who have specific expertise in this area, before you assign these patients to medical specialist with a more general orthopedic background.

24. Centralization
'Treat geographically dispersed human resources as if they are centralized'

This principle is explicitly aimed at exploiting the benefits of a Workflow Management System (WfMS). After all, when a WfMS takes care of assigning work to resources it has become less relevant where these resources are located geographically. In this sense, this principle is a special form of the "42. Integral technology" principle. The specific advantage of this measure is that resources can be committed more flexibly, which gives a better utilization and possibly a better throughput time. The disadvantages are similar to those of the integral technology principle.

Example:
Introduce a Workflow Management System to allocate the assessment of imaging images to experts who are working at two different locations.

25. Split responsibilities
'Avoid assignment of task responsibilities to people from different functional units'

The idea behind this principle is that tasks for which different departments share responsibility are more likely to be a source of neglect and conflict. Reducing the overlap in responsibilities should lead to a better quality of task execution. Also, a higher responsiveness to available work may be developed so that customers / patients are served quicker. On the other hand, reducing the effective number of resources who are available for a work item may have a negative effect on its throughput time, as more queuing may occur.

Example:
The anesthesiologist is fully responsible for the pre-operative assessment and the surgeon is fully responsible for writing the discharge letter.

26. Numerical involvement
'Minimize the number of departments, groups and persons involved in a process'

Applying this principle should lead to less coordination problems. Less time spent on coordination makes more time available for the processing of orders / patients. Reducing the number of departments may lead to less split responsibilities, with similar pros and cons as the split responsibilities principle. In addition, smaller numbers of specialized units may prohibit the build of expertise and routine.

Example:
All diagnostic activities regarding rectum cancer are assigned to internists (and no longer to surgeons).

27. Resource adjustment (HR)
'Consider changing the number of human resources'

The obvious effect of extra resources is that there is more capacity for handling orders / patients, in this way reducing queue time. It may also help to implement a more flexible assignment policy. Of course, hiring or buying extra resources has its costs. These effects are exactly countered by reducing the number of human resources.

Example:
Hire an additional nurse.

28. Specialist-generalist (HR)
'Consider to make human resources more specialized or more generalist'

Resources may be turned from specialists into generalists or the other way round. A specialist resource can be trained for other qualifications; a generalist may be assigned to the same type of work for a longer period of time, so that his / her other qualifications become obsolete. When the redesign of a new process is considered, application of this principle comes down to considering the specialist–generalist ratio of new hires. A specialist builds up routine more quickly and may have a more profound knowledge than a generalist. As a result, he or she works quicker and delivers higher quality. On the other hand, the availability of generalists adds more flexibility to the process and can lead to a better utilization of resources and a reduction of throughput times.

Example:
Train all nurses in such a way that they are able to do intake of the patients as well as monitoring the hearth activity of the patient (ECG).

29. Empower
'Give workers most of the decision-making authority and reduce middle management'

In traditional processes, substantial time may be spent on authorizing work that has been done by others. When workers are empowered to take decisions independently, it may result in smoother operations with lower throughput times. The reduction of middle management from the process also reduces the labor costs spent on the processing of orders / patients. A drawback may be that the quality of the decisions is lower and that obvious errors are no longer found. If bad decisions or errors result in rework, the costs of handling may actually increase compared to the original situation.

Example:
The assistant of the general practitioner is authorized to fully take care of patients with straightforward complaints.

30. Substitution (HR)
'Replace expensive human resources with less expensive ones'

The premise of this substitution principle is that human resources are often over-qualified for the tasks to be executed. Consequently, labor cost savings are possible by hiring less expensive (and less qualified) employees for several tasks to be executed. A drawback of this principle is that the quality of task execution might decrease. Also, substitution might have a negative impact on the speed of task execution.

Example:
Replace an orthopedic surgeon by a nurse practitioner who is responsible for the intake and after-care of orthopedic patients.

F. Facilities, equipment, and material

The principles in the *facilities, equipment, and material* category are mainly concerned with the number and types of available facilities, equipment, and material and the way these non-human resources are allocated to tasks.

31. Flexible assignment (NHR)
'Assign non-human resources in such a way that maximal flexibility is preserved for the near future'

For example, if a task can be executed by either of two available non-human resources, assign it to the most specialized resource. In this way, the possibilities to have the free, more generic-equipped non-human resource available for another task are maximal. The advantage of this principle is that the overall queue time is reduced: it is less probable that the order / patient has to wait for the availability of a specific non-human resource. Another advantage is that the most specialized non-human resources are most often in use, which may result in a higher quality. Note that this principle is the "non-human resource" variant of the "23. Flexible assignment (HR)" principle.

<u>Example:</u>
Assign orthopedic patients to the dedicated orthopedic surgery rooms, before assigning them to the multi-purpose surgery rooms.

32. Buffering (NHR)
'Consider to buffer equipment and material'

Obtaining equipment and materials from other parties is often a time-consuming part in a process. By buffering / creating an inventory of equipment of these non-human resources throughput times can be reduced. However, costs are involved in keeping an inventory.

<u>Example:</u>
Keep a sufficient inventory of sterile materials in an internal warehouse in close proximity of the surgery rooms.

33. Resource adjustment (NHR)
'Consider changing the number of involved non-human resources'

The obvious effect of extra non-human resources or increasing the production time of these resources is that there is more capacity for handling orders / patients, in this way reducing queue time. It may also help to implement a more flexible assignment policy. Of course, hiring or buying extra resources and increasing production times are costly. These effects are exactly countered by reducing the number of non-human resources. This principle can be seen as the "non-human resource" variant of the "27. Resource adjustment (HR)" principle.

<u>Example:</u>
Purchase a new MRI scanner.

34. Specialist-generalist (NHR)
'Consider to replace non-human resources with more specialized or more generic-equipped ones'

Specialized non-human resources can be used for a more limited set of tasks than generic-equipped non-human resources. Specialized non-human resources are typically able to improve the speed of task execution and deliver higher quality. On the other hand, the availability of generic-equipped non-human resources adds more flexibility to the process and can lead to a better utilization of resources and a reduction of throughput times. This principle is the "non-human resource" variant of the "28. Specialist / generalist (HR)" principle.

Example:
Equip a number of surgery rooms in such a way that these rooms can be used to treat different patient groups.

35. Substitution (NHR)
'Replace expensive non-human resources with less expensive ones'

The premise of this substitution principle is that facilities, equipment, and material are often over-equipped for the tasks to be executed. As a consequence, cost savings are possible by purchasing less expensive (and less-equipped) non-human resources for several tasks to be executed. This kind of substitution might have a negative impact on the quality and speed of task execution. This principle is the "non-human resource" variant of the "30. Substitution (HR)" principle.

Example:
Replace (due to a decrease in patient demand) an expensive MRI scanner at the end of its life-time with a less expensive one that is able to deal with less patients per hour.

36. Copying
'Consider to use inexpensive copies of non-human resources instead of expensive original ones'

Instead of purchasing an expensive non-human resource, it is sometimes possible to purchase or develop a simple, inexpensive copy of it without negative consequences for the quality of the service delivery.

Example:
Copy the electronic patient record as introduced in another hospital instead of developing a new electronic patient record from scratch.

37. Sustainable use
'Consider to make use of material with reusable, dissolving, or evaporating characteristics'

Reusing materials and making use of material that has dissolving or evaporating characteristics is not only an environment-friendly solution, but also enables cost and throughput time reduction. However, the purchase of sustainable non-human resources is often costly.

Example:
Make use of self-dissolving stitches for meniscus repair.

G. Information

The principles in the *information* category focus on the way information is used and/or created.

38. Control addition
'Check the completeness and correctness of incoming materials and check the output before it is send to customers (patients)'

This principle promotes the addition of controls to a process. It may lead to a higher quality of the process execution and, as a result, to less required rework. Obviously, an additional control will require time and will absorb resources. Note the contrast of the intent of this principle with that of the "8. Task elimination" principle and the similarities between the control addition principle and the "9. Prior counteraction" principle. Whereas the control addition principle focuses on checking information that is available, the prior counter action principle focuses on adding task that typically provide new information in order to prevent the occurrence of an undesirable situation or to reduce its impact.

Example:
The nurse checks the discharge letter before it is send to the general practitioner.

39. Buffering (I)
'Instead of requesting information from an external source, buffer it by subscribing to updates'

Obtaining information from other parties is a major time-consuming part in many processes. By having information directly available when it is required, throughput times may be substantially reduced. However, costs may be involved in subscribing for periodic updates and storage of information. Note that this principle is a weak form of the "3. Integration" principle and can be seen as the information variant of the "32. Buffering (NHR)" principle.

Example:
Store the information regarding all blood results in the patient's personal health record in such a way that these results are directly available during subsequent consultations with any healthcare provider.

40. Feedback
'Consider introducing feedback'

Providing feedback to employees (real-time or afterwards) with regard to process performance, supports employees in executing activities more efficiently and effectively. If feedback is already provided, changing the frequency of providing feedback can be considered. By providing feedback more frequently, performance problems can be tackled faster.

Example:
Invite patients to fill-in a patient satisfaction questionnaire after the oncology treatment.

H. Information and communication technology

The principles in the *information and communication technology* category focus on how information and communication technology is used in the process.

41. Task automation
'Consider automating tasks'

A particular positive result of automating tasks may be that tasks can be executed faster, with less costs, and with a better result. An obvious disadvantage is that the development of a system that performs a task may be very costly. Generally speaking, a system performing a task is also less flexible in handling variations than a human resource. Instead of fully automating a task, automated support for the resource executing the task may also be considered.

Example:
Introduce a barcode-system to automatically check the identity of the blood transfusion patient.

42. Integral technology
'Try to elevate physical constraints in a process by applying new technology'

In general, new technology can offer all kinds of positive effects, such as throughput time reduction and a better quality of service. The purchase, development, implementation, training, and maintenance efforts related to technology are obviously costly. In addition, new technology may arouse fear with workers or may result in other subjective effects; this may decrease the quality of the process.

Example:
Introduce a digital performance board that shows the number and urgency category of waiting patients at the emergency department.

I. Physical lay-out

The principles in the *physical lay-out* category focus on the physical arrangement of the process.

43. Reconstruction
'Consider reconstructing the physical lay-out'

By reconstructing the physical lay-out of the process, walking distances can be reduced. In this way, it is possible to increase productivity and reduce throughput times. Certainly, costs will be involved in making changes to the physical lay-out.

Example:
Do not make use of a central preparation- and after-care room, but create one preparation room and one after-care room in close proximity to each endoscopic treatment room.

44. Flexible lay-out
'Make the physical lay-out flexible'

Creating a flexible lay-out is a specific variant of the "43. Reconstruction" principle. Using a physical lay-out that can be easily adapted (e.g. by making use of movable parts), makes it possible to quickly react to changes in volume/case-mix of patients. The other advantages and disadvantages are similar to the reconstruction principle.

Example:
Make use of flexible partitions at nursing wards in order to treat multiple patients in the same room (if necessary) without negative consequences for patient privacy.

45. Physical shortcut
'Introduce physical shortcut possibilities'

Introducing physical shortcut possibilities is a specific variant of the "43. Reconstruction" principle. By introducing these shortcuts, walking distances can be reduced with productivity increases and throughput time reduction as a consequence. Certainly, costs are involved in creating these shortcuts.

Example:
Create an extra door between two endoscopic treatment rooms in order to make switching between two rooms easier for employees.

Appendix D.1

Boolean expression cross-case analysis Chapter 5

In this appendix, we discuss the Boolean expression of the cross-case analysis that was used for searching potentially relevant studies.

In line with the Appendix A.1 and Appendix B.1, the Boolean expression was based on the research objective and derived from the thesaurus terms of three electronic databases, i.e. ABI/Inform, INSPEC, and Medline. The elements “redesign”, “process”, and “perioperative” were derived from the research objective and related scoping decisions. A structured scan of the thesaurus trees of all electronic databases was again performed to discover related thesaurus terms for all these elements. After obtaining the thesaurus terms, we identified additional synonyms and acronyms by means of a general thesaurus, acronym library, and trial searches. Finally, advanced search options like Boolean operators and truncation symbols were used to construct the free text search term. This procedure resulted in a Boolean expression consisting of four parts:

(([process] AND [redesign]) OR [process redesign]) AND [perioperative]

Each part in the above Boolean expression surrounded by the ([ ]) symbol is itself a Boolean expression consisting of synonyms and abbreviations. For each part, the complete Boolean expression is shown in Table D.1.

Part	Complete Boolean expression
Process	business model: OR care ADJ3 continuit: OR care ADJ3 continuum: OR case management OR chain: OR delivery system: OR network: OR operation: OR order fulfil: OR order processing OR organi#ational model: OR pathway: OR patientflow: OR patient flow OR process OR processes OR product: line: OR service: OR workflow: OR work flow:
Redesign	chang: OR CI OR CQI OR CQM OR design: OR develop: OR engineer: OR improv: OR innovat: OR invent OR inventi: OR optim: OR Quality Management OR redesign: OR reengineer: OR re-engineer: OR reform: OR reorgani: OR restructur: OR streamlin: OR total quality OR TQM
Process redesign	BPR OR clinical ADJ2 path: OR critical ADJ2 path: OR disease management OR integrated delivery OR integrated ADJ2 path: OR kaizen OR lean OR patient ADJ2 centered ADJ2 care OR patient ADJ2 focused ADJ2 care OR six sigma
Perioperative*	operating OR operative OR perioperative OR surgery OR surgical

Table D.1.1. Overview Boolean expressions. The Boolean expressions in this table are used in the INSPEC and Medline database. In the ABI/Inform database slightly different truncation symbols are used. * In the INPSEC database, we extended this Boolean expression with a subject heading: “OR exp surgery/”. In the Medline database, we extended this Boolean expression with the Mesh heading: “OR exp operating room/”.

The free text search in titles was complemented with the use of high-level subject headings and classification codes in INSPEC and Mesh headings and sub-headings in Medline. Analogously to Appendix A.1 and Appendix B.1, we did not use headings in ABI/Inform due to the absence of a clear hierarchical tree structure of headings. The detailed search filters of the three electronic databases, including the selected headings, are shown below.

General:

Date electronic searches:
14/01/2012

ABI/Inform:

Filter settings advanced search:
- Database: ABI/INFORM GLOBAL
- Data range: after this data: 01/01/1990
- Limit results to: Scholarly journal, including peer-reviewed
- Exclude: Book reviews; Dissertations; Newspapers

INSPEC:

Filter settings multi-field search:
- English language
- Abstract
- Publication year: 1990 - Current
- Publication types: Conference paper; Conference Proceedings; Journal paper
- Subject headings:
  - Systems analysis (not exploded)
    - Systems re-engineering
  - Business process re-engineering
  - Customer services
  - Management of change
  - Organizational aspects (not exploded)
  - Production management (not exploded)
    - Process planning
    - Logistics
  - Quality management (not exploded)
    - Total quality management
    - Continuous improvement
    - Six sigma (quality)
    - Innovation management
  - Supply chain management (not exploded)
  - Administrative data processing
  - Operations research (not exploded)
  - Order processing
  - Management science (not exploded)
  - Health care
  - Patient care
  - Systems engineering
  - Production engineering
  - Industrial engineering
  - Value engineering
  - Process design
  - Optimal systems
  - Constraint theory
  - Constraint handling
  - Lean production
  - Benchmark testing

- Classification codes:
    - Systems theory applications in economics and business
    - Systems theory applications in industry
    - Business and administration (not exploded)
        - Office automation
        - Public administration
        - Medical administration
        - Manufacturing and industrial administration
        - Administration of other service industries
    - Business and professional IT applications
    - Health care applications of IT
    - Industrial and manufacturing applications of IT
    - General topics in manufacturing and production engineering (not exploded):
        - Management and business
        - Organizational aspects
        - Management issues
        - Information technology applications (not exploded)
            - Industrial applications of IT
            - Business applications of IT
    - Production management
    - Research and development
    - Design
    - Manufacturing systems
    - System theory applications

Medline:

Filter settings multi-field search:

- English language
- Abstract
- Publication year: 1990 - Current
- Mesh headings:
    - *Information sciences / Information science* / Systems analysis
    - *Health care / Health care facilities, manpower and services* / Capacity building
    - *Health care / Health care facilities, manpower and services* / Health facilities
    - *Health care / Health care facilities, manpower and services* / Health services
    - *Health care / Health care economics and organizations* / Health planning
    - *Health care / Health service administration* / Organization and administration
    - *Health care / Health service administration* / Patient care management
    - *Health care / Health service administration* / Quality of care
    - *Health care / Health care quality, access and evaluation* / Delivery of health care
    - *Health care / Health care quality, access and evaluation* / Health services research
    - *Health care / Health care quality, access and evaluation* / Health care quality assurance
    - *Health care / Health care quality, access and evaluation* / Quality of health care
- Sub-headings
    - ec (economics);
    - og (organization & administration);
    - st (standards);
    - sd (supply and distribution);
    - ut (utilization)

Appendix D.2

Screening criteria cross-case analysis Chapter 5

This appendix contains an overview of all relevance and quality screening criteria that were used as part of the cross-case analysis.

Inclusion (I) and exclusion (E) criteria

1. Does the study report about an initiative in a real-life context? *(I)*
2. Does the described initiative target a perioperative process? *(I)*
3. Does the described initiative aim at generating process improvement ideas *(I)*
    a. Does the described initiative only aim at modeling or analyzing the AS-IS situation? *(E)*
    b. Does the described initiative only aim at improving patient scheduling? *(E)*
4. Does the described initiative discuss process improvement ideas? *(I)*

Table D.2.1. Overview relevance criteria of cross-case analysis.

Inclusion (I) and exclusion (E) criteria
1. Does the study provide a clear actionable description of at least one process improvement proposal? *(I)*

Table D.2.2. Overview quality criteria of cross-case analysis.

Appendix D.3

Data extraction form cross-case analysis Chapter 5

In this appendix, we provide the data extraction form that was used to extract relevant data fragments from all studies included in the cross-case analysis.

Process improvement proposals	
Data extraction element	**Definition**
1. Process improvement proposal	An actionable description of a process improvement idea.
Case study characteristic	
Data extraction element	**Definition**
1. Type of source	Type of source (Journal paper / Conference paper / Book chapter / Technical report) of the study
2. Label research area	The business process redesign related label that is used in the study (e.g. clinical pathways, lean, six sigma)
3. Country	The country where the business process redesign initiative took place
4. Annual patient volume	The annual patient volume of the patient group that was the subject of investigation

Table D.3.1. Data extraction form of cross-case analysis.

Appendix D.4

Implicit usage of RePro principles cross-case analysis Chapter 5

This appendix presents an overview with regard to the implicit usage of RePro principles in the selected sample of case studies.

RePro principle	RePro category	Group	No. of implicit applica-tions of principles	No. of case studies implicitly applying principle
10. Prior action	C. Tasks	TRIZ	19	13
42. Integral technology	H. Information and communication technology	BPR	18	8
28. Specialist-generalist (HR)	E. Human resources	BPR	17	10
34. Specialist-generalist (NHR)	F. Facilities, equipment, and material	TRIZ	13	10
43. Reconstruction	I. Physical lay-out	TRIZ	13	9
9. Prior counteraction	C. Tasks	TRIZ	9	8
18. Parallelism	D. Task order and timing	BPR	8	5
11. Triage	C. Tasks	BPR	6	4
16. Resequencing	D. Task order and timing	BPR	6	4
33. Resource adjustment (NHR)	F. Facilities, equipment, and material	TRIZ	5	5
New. Information provision	G. Information	New	5	5
6. Interfacing	B. External environment	BPR	5	3
27. Resource adjustment (HR)	E. Human resources	BPR	4	4
29. Empower	E. Human resources	BPR	4	4
8. Task elimination	C. Tasks	BPR	4	3
41. Task automation	H. Information and communication technology	BPR	4	3
30. Substitution (HR)	E. Human resources	TRIZ	4	2
32. Buffering (NHR)	F. Facilities, equipment, and material	TRIZ	3	2
1. Control relocation	A. Customers	BPR	2	2
7. Order types	C. Tasks	BPR	2	2
12. Task composition	C. Tasks	BPR	2	2
19. Exception	D. Task order and timing	BPR	2	2
21. Customer teams	E. Human resources	BPR	2	2
25. Split responsibilities	E. Human resources	BPR	2	2
40. Feedback	G. Information	TRIZ	2	2
3. Integration	A. Customers	BPR	1	1
20. Order assignment	E. Human resources	BPR	1	1
26. Numerical involvement	E. Human resources	BPR	1	1
35. Substitution (NHR)	F. Facilities, equipment, and material	TRIZ	1	1
38. Control addition	G. Information	BPR	1	1
44. Flexible lay-out	I. Physical lay-out	TRIZ	1	1
45. Physical shortcut	I. Physical lay-out	TRIZ	1	1
2. Contact reduction	A. Customers	BPR		
4. Trusted party	B. External environment	BPR		
5. Outsourcing	B. External environment	BPR		
13. Order-based work	D. Task order and timing	BPR		
14. Periodic action	D. Task order and timing	TRIZ		
15. Shortcut	D. Task order and timing	TRIZ		
17. Knock-out	D. Task order and timing	BPR		
22. Case manager	E. Human resources	BPR		
23. Flexible assignment (HR)	E. Human resources	BPR		
24. Centralization	E. Human resources	BPR		
31. Flexible assignment (NHR)	F. Facilities, equipment, and material	TRIZ		
36. Copying	F. Facilities, equipment, and material	TRIZ		
37. Sustainable use	F. Facilities, equipment, and material	TRIZ		
39. Buffering (I)	G. Information	BPR		

Table D.4.1. Implicit usage of RePro principles in selected sample of case studies.

Appendix D.5

Adjusted RePro principles Chapter 5

This appendix presents an overview of the adjusted RePro principles.

RePro principle	RePro category	Adjustment	Updated RePro principle
6. Interfacing	B. External environment	Content adjustment: principle can also be used in the context of *internal* information transfers; principle moved to *information category*. Definition and explanation are textually adjusted.	38. Interfacing
11. Triage	C. Tasks	Textual adjustments: Title (new: Task differentiation), definition, and explanation are adjusted.	10. Task differentiation
15. Shortcut	D. Task order and timing	Textual adjustments: Title (new: Process-status-dependent adjustments), definition, and explanation are adjusted.	14. Process-status-dependent adjustments
17. Knock-out	D. Task order and timing	Textual adjustment: Explanation is adjusted.	16. Knock-out
23. Flexible assignment (HR)	E. Human resources	Textual adjustment: Title (new: Forward-looking assignment (HR) is adjusted.	22. Forward-looking assignment (HR)
24. Centralization	E. Human resources	Textual adjustments: Title (new: Geographic centralization), definition, and explanation are adjusted.	23. Geographic centralization
30. Substitution (HR)	E. Human resources	Content adjustment: opposite variant of principle is added. Definition and explanation are textually adjusted.	29. Substitution (HR)
31. Flexible assignment (NHR)	F. Facilities, equipment, and material	Textual adjustment: Title (new: Forward-looking assignment (NHR) is adjusted.	30. Forward-looking assignment (NHR)
35. Substitution (NHR)	F. Facilities, equipment, and material	Content adjustment: opposite variant of principle is added. Definition and explanation of principle are textually adjusted.	34. Substitution (NHR)
39. Buffering (I)	G. Information	Textual adjustment: Title (new: Prior storage) is adjusted.	39. Prior storage
42. Integral technology	H. Information and communication technology	Textual adjustments: Definition and explanation are adjusted.	43. Integral technology
44. Flexible lay-out	I. Physical lay-out	Textual adjustment: Title (new: Flexible spatial arrangement), definition, and explanation are adjusted.	45. Flexible spatial arrangement
45. Physical shortcut	I. Physical lay-out	Textual adjustment: Title (new: Lay-out shortcut), definition, and explanation are adjusted.	46. Lay-out shortcut
New. Information provision	G. Information	New principle identified during cross-case analysis	41. Information provision

Table D.5.1. Overview of adjusted RePro principles.

Appendix D.6

Updated detailed overview of RePro principles Chapter 5

In this appendix, we provide the updated set of RePro principles, which includes all adjustments as outlined in Appendix D.5.

Level 1: Service concept

A. Customers

The principles in the *customers* category focus on improving contacts with customers.

1. Control relocation
‘Move controls towards the customers (patients)’

By moving checks and other operations that are part of a process to the customer / patient, costs can be reduced and customer satisfaction might increase. A disadvantage of this solution is a higher probability of fraud.

Example:
Ask the patient, instead of the nurse, to pick up the drugs by the hospital pharmacy.

2. Contact reduction
‘Reduce the number of contacts with customers (patients) and third parties’

The exchange of information with a customer / patient or third party is always time-consuming. Also, each contact introduces the possibility of intruding an error. Reducing the number of contacts may therefore decrease throughput time and boost quality. Note that it is not always necessary to skip certain information exchanges, but that it is also possible to combine them with limited extra costs. A disadvantage of a smaller number of contacts might be the loss of essential information, which is a quality issue. Combining contacts may also result in the delivery or receipt of too much data.

Example:
Combine the hospital visit “recording of the heart activity (ECG)” and the hospital visit “cycling test”. In the new situation, one hospital visit takes place in which both diagnostic tests are performed successively during one session.

3. Integration
'Consider the integration with a process of the customer (patient) or a supplier'

This principle is based on the supply-chain concept. An improved collaboration between the transaction partners (by performing intermediate reviews) enables possibilities for reducing costs and throughput times. The drawback of integration is that mutual dependence grows, and flexibility may decrease as result.

Example:
The treatment plan of an oncology patient is determined by the internist in a discussion session with the patient's general practitioner.

B. External environment

The principles in the *external environment* category address the collaboration and communication with third parties.

4. Trusted party
'Instead of determining information oneself, use results of a trusted party'

Some decisions or assessments that are made within processes are not specific for the process these are part of. Other parties may have determined the same information in another context. Obviously, by making use of the information of a trusted party costs and throughput times can be reduced. On the other hand, the quality of the process becomes dependent upon the quality of some other party's work. Some coordination effort with trusted parties is also likely to be required, which diminishes flexibility.

Example:
Trust the 24-hours blood pressure monitoring data as provided by a general practitioner, instead of re-executing the monitoring as part of the hospital diagnosis trajectory.

5. Outsourcing
'Consider outsourcing a process as a whole or parts of it'

Another party may be more efficient in performing the same work. The obvious aim of outsourcing work is to reduce costs. A drawback may be that quality decreases. Outsourcing also requires more coordination efforts and will make the process more complex. Note that this principle differs from the "4. Trusted party" principle. When outsourcing, a task is executed at run time by another party. The "4. Trusted party" principle allows for the use of a result in the (recent) past.

Example:
Outsource the assessment of imaging images to a specialized center in India.

Level 2: Main process design

C. Tasks

The principles in the *task* category focus on the tasks that are part of the process.

6. Order types
'Determine whether tasks are related to the same type of order (patient group) and, if necessary, distinguish new processes'

Ignoring that several parts of a process are not specific for certain type of orders / patient groups negatively affects the efficiency of the process. Applying this principle may result in faster processing times and less costs. Yet, it may also result in more coordination problems between the different processes and less possibilities for rearranging the process as a whole.

Example:
Create separate perioperative processes (everything happening just before, during and just after surgery) for children and adults.

7. Task elimination
'Eliminate unnecessary tasks from the process'

Several tasks within a process do not provide value from a customer's / patient's point of view, such as control tasks and redundant tasks. The aim of this principle is to increase the speed of processing and reduce the costs of handling an order. An important drawback may be that the quality of the service deteriorates.

Example:
Stop providing paper-based, drug-related forms when all patients use a digital interface.

8. Prior counteraction
'Add tasks to prevent the occurrence of an undesirable situation or to reduce its impact'

"Prevention is better than cure" is the premise of this principle. Certainly, costs are involved in adding tasks. This investment can be recouped by throughput time reduction, quality improvement, and/or cost reduction due to preventing an undesirable situation or reducing the impact of such an event.

Example:
Perform a rigorous pre-operative screening before a patient receives open-heart surgery.

9. Prior action
'Perform tasks before they need to be executed, or add tasks to smooth the execution of remaining tasks in the process'

Performing tasks before they need to be executed or adding tasks to smooth the execution of remaining tasks in the process has similar advantages and disadvantages as the "8. Prior counteraction" principle. The difference between both principles is that the prior counteraction principle has a "prevention" focus, whereas the prior action principle has a "stimulation" focus.

Example:
Ask the patient with knee-related complaints to undress in the preparation room, while the diagnosis of another patient is still ongoing.

10. Task differentiation
'Consider the division of a general task into two or more dedicated tasks' or 'consider the integration of two or more dedicated tasks into one general task'

When applying this principle in its first most popular form, it is possible to design tasks that are better aligned with the capabilities of resources and the characteristics of the orders / patients being processed. Distinguishing dedicated tasks may improve quality and facilitate a better utilization of resources with obvious cost and time advantages. On the other hand, too much differentiation can make processes become less flexible, less efficient, and cause monotonous work with repercussions for quality. Note that this principle is in some sense similar to the "6. Order types" principle. The main interpretation of the task differentiation concept can be seen as a translation of the order type best practice on a task level.

Example:
Differentiate the provision of perioperative information for patients with and without diabetes.

11. Task composition
'Combine small tasks into composite tasks and divide large tasks into workable smaller tasks'

Combining tasks should result in the reduction of setup times, i.e. the time that is spent by a resource to become familiar with the specifics of an order / a patient. By executing a large task which used to consist of several smaller ones some positive effects may also be expected on the quality of the delivered work. On the other hand, making tasks too large may result in smaller run-time flexibility and lower quality as tasks become unworkable. Both effects are exactly countered by dividing tasks into smaller ones.

Example:
The composition of Magnetic Resonance Imaging (MRI) activities: positioning the patient and setting up the equipment are composed into one task executed by an assistant.

Level 3: Detailed process design

D. Task order and timing

The principles in the *tasks order and timing* category consider the order in which tasks are executed and the more detailed timing of task execution.

12. Order-based work
'Consider removing batch-processing and periodic activities from the process'

Some disturbances in handling a single order / patient are: (a) piling up in a batch and (b) periodic activities, i.e. activities that are only executed at specific times. Getting rid of these constraints may significantly speed up the handling of individual orders. On the other hand, efficiencies of scale can be reached by batch or periodic processing.

Example:
Do not discuss all oncology patient once a week during a multi-disciplinary meeting, but discuss every patient in a multi-disciplinary meeting immediately after arrival of all test results of the patient.

13. Periodic action
'Consider making an action periodic or changing the periodicity of an already recurrent action'

Executing activities with a certain periodicity can lead to efficiency of scales. However, this principle typically leads to an increase in throughput times. Note the contrast of the objective of this principle and the objective of the "12. Order-based work" principle.

Example:
Organize information sessions for oncology patients once a week instead of providing information during consultations with individual patients.

14. Process-status-dependent adjustments
'Introduce possibilities for adjusting the process dependent on the status of the process'

By introducing possibilities to skip process parts or adjust resource allocations under certain conditions, e.g. extreme long waiting times, throughput times can be reduced. Application of this principle might have negative consequences for the quality of the process.

Example:
Skip checking insurance data of patients at the emergency department when waiting time is long and perform these insurance checks afterwards.

15. Resequencing
'Move tasks to more appropriate places'

In existing processes, actual task orderings do not reveal the necessary dependencies between tasks. Sometimes it is better to postpone a task if it is not required for immediately following tasks, so that perhaps its execution may prove to become superfluous. This saves costs. Also, a task may be moved into the proximity of a similar task, in this way diminishing set-up times.

Example:
Take blood from a patient before the consultation with the medical specialist instead of after the consultation, in order to enable a discussion of the lab results during the consultation.

16. Knock-out
'Order knock-outs in an increasing order of effort and in a decreasing order of termination probability'

A typical part of a process is checking whether additional (treatment) activities are needed. Any check may lead to termination of further treatment: the knock-out. If there is freedom in choosing the order in which different checks are performed, the check that has the most favorable ratio of expected termination (knock-out) probability versus the expected effort should be pursued. By first executing the checks that do not require a lot of effort but have a high termination probability, the least costly process execution is achieved. There is no obvious drawback of this principle, although it may not always be possible to freely order these kinds of checks. Also, implementing this principle may result in a (part of a) process that takes a longer throughput time than a full parallel execution of checks. Note that the knock-out principle is a specific form of the “15. Resequencing” principle.

Example:
Perform the lab-test before executing the time-consuming CT-scan (assumption: termination probability of further diagnostics/treatment is equal for both tests).

17. Parallelism
'Consider whether tasks may be executed in parallel'

The obvious effect of putting (sequential) tasks in parallel is that the throughput time may be considerably reduced. A drawback of introducing more parallelism in a process that incorporates possibilities of knock-outs is that the costs of process execution may increase. Also, the management of processes with concurrent behavior can become more complex, which may introduce errors or restrict run-time adaptations.

Example:
Do not wait with cleaning the surgery room till the patient has left the surgery room, but execute these activities in parallel.

18. Exception
'Design processes for typical orders (patients) and isolate exceptional orders (patients) from normal flow'

Exceptions may seriously disturb normal operations. An exception will require workers to get acquainted with the specifics of the exception, although they may not be able to handle it. Set-up times are then wasted. Isolating exceptions will make the handling of normal orders / patients more efficient. Isolating exceptions may possibly increase the overall performance as specific expertise can be build up by workers working on the exceptions. The price paid is that the process will become more complex, possibly decreasing its flexibility. Also, if no special knowledge is developed to handle the exceptions (which is costly) no major improvements are likely to occur.

Example:
Refer surgery patients with a Body Mass Index (BMI) > 40 to a specialized nurse.

E. Human resources

The principles in the *human resources* category are mainly concerned with the number and types of available human resources and the way they are allocated to tasks.

19. Order assignment
‘Let workers perform as many steps as possible for single orders (patients)’

By using order / patient assignment in the most extreme form, for each task execution the resource is selected from the ones capable of performing it who has worked on the order / for the patient before — if any. The obvious advantage of this principle is that this person will get acquainted with the case and will need less set-up time. An additional benefit may be that the quality of service is increased. On the negative side, the flexibility of resource allocation is seriously reduced. An order / a patient may experience substantial queue time when the person to whom the order / patient is assigned is not available.

Example:
The nurse who is responsible for the execution of the intake of the patient is also responsible for executing all checks and discharging the patient.

20. Customer teams
‘Consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of orders (patients)’

This principle is a variation on the “19. Order assignment” principle. Depending on its exact desired form, the customer team principle may be implemented by the order assignment principle. Also, a customer team may involve more workers with the same qualifications, in this way relaxing the strict requirements of the order assignment principle. Advantages and disadvantages are similar to those of the order assignment principle. In addition, working as a team may improve the attractiveness of the work.

Example:
Assign to each oncology patient, one surgeon, one internist, and two nurses who will take care of the complete handling of the activities of the patient.

21. Case manager
‘Appoint one person as responsible for the handling of an order (a patient), the case manager’

The case manager is responsible for a specific order or patient, but he or she is not necessarily the (only) resource who will work on it. Contrary to the “19. Order assignment” principle the emphasis is on the management of the process and not on its execution. The most important aim of the principle is to improve upon the external quality of a process. The process will become more transparent from the viewpoint of a customer as the case manager provides a single point of contact. This positively affects customer satisfaction. It may also have a positive effect on the internal quality of the process, as someone is accountable for correcting mistakes. Obviously, the assignment of a case manager has financial consequences as capacity must be devoted to this job.

<u>Example:</u>
Assign to each oncology patient a nurse practitioner who is responsible for all activities that are performed for the patient.

22. Forward-looking assignment (HR)
‘Assign human resources in such a way that maximal flexibility is preserved for the near future’

For example, if a task can be executed by either of two available resources, assign it to the most specialized resource. In this way, the possibilities to have the free, more generalist resource execute another task are maximal. The advantage of this principle is that the overall queue time is reduced: it is less probable that the order / patient has to wait for the availability of a specific resource. Another advantage is that the workers with the highest specialization can be expected to take on most of the work, which may result in higher quality. The disadvantages of this principle can be diverse. For example, work load may become unbalanced resulting in less job satisfaction. Also, possibilities for specialists to evolve into generalists are reduced.

<u>Example:</u>
Assign patients with knee-related problems to medical specialists who has specific expertise in this area, before you assign these patients to medical specialist with a more general orthopedic background.

23. Geographic centralization
‘Arrange (technological) support to enable effective collaboration between geographically dispersed human resources’

By making use of information and communication technology that takes care of assigning work to resources, it becomes less relevant where these resources are located geographically. In this sense, this principle is a special form of the “43. Integral technology” principle. The specific advantage of this principle is that resources can be committed more flexibly, which gives a better utilization and possibly a better throughput time. The disadvantages are similar to those of the integral technology principle.

<u>Example:</u>
Introduce a Workflow Management System to allocate the assessment of imaging images to experts who are working at two different locations.

24. Split responsibilities
'Avoid assignment of task responsibilities to people from different functional units'

The idea behind this principle is that tasks for which different departments share responsibility are more likely to be a source of neglect and conflict. Reducing the overlap in responsibilities should lead to a better quality of task execution. Also, a higher responsiveness to available work may be developed so that customers / patients are served quicker. On the other hand, reducing the effective number of resources who are available for a work item may have a negative effect on its throughput time, as more queuing may occur.

<u>Example:</u>
The anesthesiologist is fully responsible for the pre-operative assessment and the surgeon is fully responsible for writing the discharge letter.

25. Numerical involvement
'Minimize the number of departments, groups and persons involved in the process'

Applying this principle should lead to less coordination problems. Less time spent on coordination makes more time available for the processing of orders / patients. Reducing the number of departments may lead to less split responsibilities, with similar pros and cons as the split responsibilities principle. In addition, smaller numbers of specialized units may prohibit the build of expertise and routine.

<u>Example:</u>
All diagnostic activities regarding rectum cancer are assigned to internists (and no longer to surgeons).

26. Resource adjustment (HR)
'Consider changing the number of human resources'

The obvious effect of extra resources is that there is more capacity for handling orders / patients, in this way reducing queue time. It may also help to implement a more flexible assignment policy. Of course, hiring or buying extra resources is costly. These effects are exactly countered by reducing the number of human resources.

<u>Example:</u>
Hire an additional nurse.

27. Specialist-generalist (HR)
'Consider to make human resources more specialized or more generalist'

Resources may be turned from specialists into generalists or the other way round. A specialist resource can be trained for other qualifications; a generalist may be assigned to the same type of work for a longer period of time, so that her / his other qualifications become obsolete. When the redesign of a new process is considered, application of this principle comes down to considering the specialist–generalist ratio of new hires. A specialist builds up routine more quickly and may have a more profound knowledge than a generalist. As a result he or she works quicker and delivers higher quality. On the other hand, the availability of generalists adds more flexibility to the process and can lead to a better utilization of resources and a reduction of throughput times.

Example:
Train all nurses in such a way that they are able to do the intake of the patients as well as monitoring the hearth activity of the patient (ECG).

28. Empower
'Give workers most of the decision-making authority and reduce middle management'

In traditional processes, substantial time may be spent on authorizing work that has been done by others. When workers are empowered to take decisions independently, it may result in smoother operations with lower throughput times. The reduction of middle management from the process also reduces the labor costs spent on the processing of orders / patients. A drawback may be that the quality of the decisions is lower and that obvious errors are no longer found. If bad decisions or errors result in rework, the costs of handling may actually increase compared to the original situation.

Example:
The assistant of the general practitioner is authorized to fully take care of patients with straightforward complaints.

29. Substitution (HR)
'Consider replacing expensive human resources with less expensive ones when human resources are overqualified for tasks to be executed and consider replacing poorly-performing human resources with more expensive and more qualified ones in order to improve process performance'

The premise of the first version of the substitution principle is that human resources are often over-qualified for the tasks to be executed. Consequently, labor cost savings are possible by hiring less expensive (and less qualified) employees for several tasks to be executed. A drawback of this principle is that the quality of task execution might decrease. Also, substitution might have a negative impact on the speed of task execution. Vice versa, replacing inexpensive and poorly-performing human resources with more expensive and more qualified ones can be a means to improve quality and reduce process- and throughput times.

Example:
Replace an orthopedic surgeon by a nurse practitioner who is responsible for the intake and after-care of orthopedic patients.

F. Facilities, equipment, and material

The principles in the *facilities, equipment, and material* category are mainly concerned with the number and types of available facilities, equipment, and material and the way these non-human resources are allocated to tasks.

30. Forward-looking assignment (NHR)
'Assign non-human resources in such a way that maximal flexibility is preserved for the near future'

For example, if a task can be executed by either of two available non-human resources, assign it to the most specialized resource. In this way, the possibilities to have the free, more generic-equipped non-human resource available for another task are maximal. The advantage of this principle is that the overall queue time is reduced: it is less probable that the order / the patient has to wait for the availability of a specific non-human resource. Another advantage is that the most specialized non-human resources are most often in use, which may result in higher quality. Note that this principle is the "non-human resource" variant of the "22. Forward-looking assignment (HR)" principle.

<u>Example:</u>
Assign orthopedic patients to the dedicated orthopedic surgery rooms, before assigning them to the multi-purpose surgery rooms.

31. Buffering (NHR)
'Consider to buffer equipment and material'

Obtaining equipment and materials from other parties is often a time-consuming part in a process. By buffering / creating an inventory of these non-human resources throughput times can be reduced. However, costs are involved in keeping an inventory.

<u>Example:</u>
Keep a sufficient inventory of sterile materials in an internal warehouse in close proximity of the surgery rooms.

32. Resource adjustment (NHR)
'Consider changing the number of non-human resources'

The obvious effect of extra non-human resources or increasing the production time of these resources is that there is more capacity for handling orders / patients, in this way reducing queue time. It may also help to implement a more flexible assignment policy. Of course, hiring or buying extra resources and increasing production times is costly. These effects are exactly countered by reducing the number of non-human resources. This principle can be seen as the "non-human resource" variant of the "26. Resource adjustment (HR)" principle.

<u>Example:</u>
Purchase an extra MRI scanner.

33. Specialist-generalist (NHR)
'Consider to replace non-human resources with more specialized or more generic-equipped ones'

Specialized non-human resources can be used for a more limited set of tasks than generic-equipped non-human resources. Specialized non-human resources are typically able to improve the speed of task execution and deliver higher quality. On the other hand, the availability of generic-equipped non-human resources adds more flexibility to the process and can lead to a better utilization of resources and a reduction of throughput times. This principle is the "non-human resource" variant of the "27. Specialist / generalist (HR)" principle.

Example:
Equip a number of surgery rooms in such a way that these rooms can be used to treat different patient groups.

34. Substitution (NHR)
'Consider replacing expensive non-human resources with less expensive ones when non-human resources are over-equipped for the tasks to be executed and consider replacing under-equipped non-human resources with more expensive and more equipped ones in order to improve process performance'

The premise of the first variant of this substitution principle is that facilities, equipment, and material are often over-equipped for the tasks to be executed. As a consequence, cost savings are possible by purchasing less expensive (and less-equipped) non-human for several tasks to be executed. This kind of substitution might have a negative impact on the quality and speed of task execution. Vice versa, replacing inexpensive and under-equipped non-human resources with more expensive and more equipped ones can be a means to improve quality and reduce process- and throughput times. This principle is the "non-human resource" variant of the "29. Substitution (HR)" principle.

Example:
Replace (due to a decrease in patient demand) an expensive MRI scanner at the end of its life-time with a less expensive one that is able to deal with less patients per hour.

35. Copying
'Consider to use inexpensive copies of non-human resources instead of expensive original ones'

Instead of purchasing an expensive non-human resource, it is sometimes possible to purchase or develop a simple, inexpensive copy of it without negative consequences for the quality of the service delivery.

Example:
Copy the electronic patient record as introduced in another hospital instead of developing a new electronic patient record from scratch.

36. Sustainable use
'Consider to make use of material with reusable, dissolving, or evaporating characteristics'

Reusing materials and making use of material that has dissolving or evaporating characteristics is not only an environment-friendly solution, but also enables cost and throughput time reduction. However, the purchase of sustainable non-human resources is often costly.

<u>Example:</u>
Make use of self-dissolving stitches for meniscus repair.

G. Information

The principles in the *information* category focus on the way information is used and/or created.

37. Control addition
'Check the completeness and correctness of incoming materials and check the output before it is send to customers'

This principle promotes the addition of controls to a process. It may lead to a higher quality of process execution and, as a result, to less required rework. Obviously, an additional control will require time and will absorb resources. Note the contrast of the intent of this principle with that of the "7. Task elimination" principle and the similarities between the control addition principle and the "8. Prior counteraction" principle. Whereas the control addition principle focuses on checking information that is available, the prior counter action principle focuses on adding task that typically provide *new* information in order to prevent the occurrence of an undesirable situation or to reduce its impact.

<u>Example:</u>
The nurse checks the discharge letter before it is send to the general practitioner.

38. Interfacing
'Consider a standardized interface for information transfers'

The idea behind this principle is that a standardized interface will diminish the probability of mistakes, incomplete applications, and unintelligible communications. Consequently, a standardized interface may result in less errors, faster processing, and less rework. A standardized interface can be considered for internal information transfers between employees as well as external information transfers with customers and third parties.

<u>Example:</u>
Invite patients to provide drug related information through a standardized interface.

39. Prior storage
'Instead of requesting information from an external source, store this information in advance by subscribing to updates'

Obtaining information from other parties is a major time-consuming part in many processes. By having information directly available when it is required, throughput times may be substantially reduced. However, costs may be involved in subscribing for periodic updates and storage of information. Note that this principle is a weak form of the "3. Integration" principle and can be seen as a specific variant of the "9. Prior action" principle and the information variant of the "31. Buffering (NHR)" principle.

Example:
Store the information regarding all blood results in the patient's personal health record in such a way that these results are directly available during subsequent consultations with any healthcare provider.

40. Feedback
'*Consider introducing feedback'*

Providing feedback to employees (real-time or afterwards) with regard to process performance, supports employees in executing activities more efficiently and effectively. If feedback is already provided, changing the frequency of providing feedback can be considered. By providing feedback more frequently, performance problems can be tackled faster.

Example:
Invite patients to fill-in a patient satisfaction questionnaire after the oncology treatment.

41. Information provision
'*Provide the customer with information about what is going to happen and related reasons'*

Customers appreciate receiving information prior or real-time in a digital of paper form about activities that are going to happen. Particularly, it is recommended to inform patients about diagnostic and treatment activities that are going to happen and the reason for executing these. This principle aims to improve the quality of the process as perceived by customers.

Example:
Provide patients with a video on a website that introduces them to the endoscopic treatment experience.

H. Information and communication technology

The principles in the *information and communication technology* category focus on how information and communication technology is used.

42. Task automation
'Consider automating tasks'

A particular positive result of automating tasks may be that tasks can be executed faster, with less costs, and with a better result. An obvious disadvantage is that the development of a system that performs a task may be very costly. Generally speaking, a system performing a task is also less flexible in handling variations than a human resource. Instead of fully automating a task, automated support for the resource executing the task may also be considered.

Example:
Introduce a barcode-system to automatically check the identity of the blood transfusion patient.

43. Integral technology
'Try to elevate physical constraints in a process by applying new information and communication technology'

In general, new information and communication technology can offer all kinds of positive effects, such as throughput time reduction (e.g. physical transport is no longer needed) and a better quality of service. The purchase, development, implementation, training, and maintenance efforts related to ICT are obviously costly. In addition, new ICT may arouse fear with workers or may result in other subjective effects; this may decrease the quality of the process.

Example:
Introduce a digital performance board that shows the number and urgency category of waiting patients at the emergency department.

I. Physical lay-out

The principles in the *physical lay-out* category focus on the physical arrangement of the process.

44. Reconstruction
'Consider reconstructing the physical lay-out'

By reconstructing the physical lay-out of the process, walking distances can be reduced. In this way, it is possible to increase productivity and reduce throughput times. Certainly, costs will be involved in making changes to the physical lay-out.

Example:
Do not make use of a central preparation- and after-care room, but create one preparation room and one after-care room in close proximity to each endoscopic treatment room.

45. Flexible spatial arrangement
'Make the spatial arrangement flexible'

Creating a flexible spatial arrangement is a specific variant of the "44. Reconstruction" principle. Using a spatial arrangement that can be easily adapted (e.g. by making use of movable parts), makes it possible to quickly react to changes in volume/case-mix of patients. The other advantages and disadvantages are similar to the reconstruction principle.

Example:
Make use of flexible partitions at nursing wards in order to treat multiple patients in the same room (if necessary) without negative consequences for patient privacy.

46. Lay-out shortcut
'Consider creating a lay-out shortcut'

Introducing a lay-out shortcut is a specific variant of the "44. Reconstruction" principle. By introducing these shortcuts, walking distances can be reduced with productivity increases and throughput time reduction as a consequence. Certainly, costs are involved in creating these shortcuts.

Example:
Create an extra door between two endoscopic treatment rooms in order to make switching between two rooms easier for employees.

Appendix E.1

Data validation measurements lab experiments Chapter 6

In this appendix, we outline the measurements that were used to evaluate inter-rater-reliability with regard to ratings / assignments for different response variables (i.e. productivity, diversity, quality, and originality). Moreover, we discuss the internal consistency of the two-item intention-to-use construct.

Response variables: inter-rater-reliability

The statistic to be used for measuring inter-rater-reliability depends on the measurement scale (i.e. nominal, ordinal, interval, or ratio) (Cooper and Schinlder 2003). For nominal and interval data, we used Cohen's kappa coefficients (Sim and Wright 2005) and intra-class correlation coefficients (McGraw and Wong 1996) respectively. For kappa coefficients, Landis and Koch (1977) have proposed the following interpretations for the strength of agreement: <= 0.0 = poor; 0.01 - 0.20 = slight; 0.21 - 0.40 = fair; 0.41 - 0.60 = moderate; 0.61 - 0.80 = substantial; 0.81-1.00 = almost perfect. Interpretations for intra-class correlation coefficients are similar.

Productivity and diversity

For both experiments, the inter-rater-reliability scores related to productivity and diversity are shown in Table E.1.1. In addition to Cohen's kappa coefficients, which correct for the agreement beyond chance, we also provide percentages of agreement between raters as measures for inter-rater-reliability. These percentages are easy to interpret, but do not correct for the agreement beyond chance

Response variable	Coding activity	Experiment 1		Experiment 2	
		Perc. of agreement	Cohen's kappa	Perc. of agreement	Cohen's kappa
Productivity	Identification redundant ideas	99.0%	0.74	98.2%	0.82
	Identification ideas not describing an improvement action	99.9%	0.80	99.5%	0.84
	Identification ideas containing multiple unrelated ideas	98.1%	0.79	99.2%	0.78
Diversity	Assignment RePro categories	92.1%	0.91	92.0%	0.91
	Assignment RePro principles	87.9%	0.64	87.7%	0.87

Table E.1.1. Inter-rater-reliability scores related to productivity and diversity.

Productivity. For each of the three productivity correction types, i.e. *redundant ideas*, *ideas not describing an improvement action*, and *ideas containing multiple unrelated ideas*, two raters independently checked whether each entered input needed to be corrected or not. In the first experiment, the percentages of agreements are 99.0%, 99.9%, and 98.1% respectively. Cohen's kappa scores show substantial agreement as well: 0.74, 0.80, and

0.79. In total, 86 out of 1401 ideas (6.1%) were corrected in the first experiment. In the second experiment, the percentages of agreements are 98.2%, 99.5% and 99.2% respectively. Cohen's kappa scores also indicate substantial to almost perfect agreement: 0.82, 0.84, and 0.78. In total, 82 out of 1292 ideas (6.3%) were corrected in the second experiment.

Diversity. Regarding the diversity outcome measures, two raters independently assigned all ideas to the *RePro categories* and the *RePro principles*. In the first experiment, the two raters agreed on 92.1% of the ideas for the RePro categories and on 87.9% of the ideas for the RePro principles. The Cohen's kappa scores show substantial to almost perfect agreement: 0.91 and 0.64. In the second experiment, the percentages of agreements are 92.0% and 87.7% respectively. Cohen's kappa scores indicate almost perfect agreement: 0.91 and 0.87.

In both experiments, we were able to assign all ideas to one of the nine RePro categories. With regard to the assignment to individual principles in the first experiment, we only were not able to assign 11 out of 1448 (0.8%) ideas to one of the existing RePro principles. In the second experiment, this was the case for 17 out of 1264 ideas (1.3%). All the ideas that could not be directly assigned to one of the existing RePro principles are related to the timing of task activities. In particular, these ideas are concerned with scheduling activities in a smarter way without changing the order of task activities. For example, one of the participants proposed to postpone the start and end of the working day for employees concerned with scheduling patients in order to prevent overwork of these employees. For further analysis purposes, we decided to assign all 28 ideas to the so-called "Smart scheduling" principle.

Quality and originality

For both experiments, the inter-rater-reliability scores related to quality and originality are shown in Table E.1.2. In addition to intra-class correlation coefficients, which offer advanced measures for inter-rater-reliability, we also report the percentages of agreement as defined by Diehl and Stroebe (1987). They consider raters to be in agreement whenever their ratings differ by no more than one point.

Response variable	**Coding activity**	**Experiment 1**		**Experiment 2**	
		Perc. of agreement (one-point difference)	**ICC**	**Perc. of agreement (one-point difference)**	**ICC**
Quality	Evaluating effectiveness on five-point Likert scale	96.6%	0.68	97.6%	0.71
	Evaluating feasibility on five-point Likert scale	97.2%	0.68	96.6%	0.82
Originality	Evaluating originality on five-point Likert scale	98.3%	0.91	96.9%	0.88

Table E.1.2. Inter-rater-reliability scores related to quality and originality.

Quality. With respect to the quality outcome measure, two raters independently scored a 10% random sample of ideas regarding *effectiveness* and *feasibility* on a five-point Likert scale. With raters considered to be in agreement whenever their ratings differed by no more than one point, agreement regarding effectiveness and feasibility in the first experiment exists for, respectively, 96.6% and 97.2% of the ideas in the random sample. The intra-class correlations are 0.68 for effectiveness and 0.68 for feasibility and indicate substantial agreement as well. In the second experiment, effectiveness ratings differ by no more than one point for 97.6% of the ideas in the random sample. With regard to feasibility ratings, this percentage is 96.6%. Intra-class correlations indicate substantial to almost perfect agreement as well. These are 0.71 for effectiveness and 0.82 for feasibility.

Originality. All ideas were scored on a five-point Likert scale for originality. In the first experiment, originality ratings differ by no more than one point for 98.3% of the ideas. The intra-class correlation is 0.91, indicating almost perfect agreement. In the second experiment, the percentage of ideas for which originality ratings differ by no more than one point is 96.9%. The intra-class correlation shows almost perfect agreement as well: 0.88.

Intention-to-use: internal consistency

In both experiments, the internal consistency of the two-item construct intention-to-use was measured by Cronbach's alpha. George and Mallery (2003) have proposed the following interpretations: < 0.5 = unacceptable; 0.50 - 0.59 = poor; 0.60 - 0.69 = questionable; 0.70 - 0.79 = acceptable; 0.80 - 0.89 = good; > 0.90 = excellent. In the first experiment, Cronbach's alpha score is 0.86, indicating good internal consistency. In the second agreement, this score is 0.77, indicating acceptable internal consistency.

Appendix E.2

Results evaluation of hypothesis test assumptions lab experiments Chapter 6

In this appendix, we outline the results of the tests that were used to check the *normality* and *homogeneity of variances assumption* with regard to all response variables in the two experiment conditions. Based on these results, we determined the test to be performed for hypothesis testing.

Figure E.2.1 and E.2.2 provide the normality test results for the response variables in experiment 1 and 2 respectively.

Tests of Normality (Experiment 1)

Condition		Shapiro-Wilk		
		Statistic	df	Sig.
Number_of_unique_ideas (productivity)	TB	,960	37	,203
	RePro	,887	44	,000
Number_of_categories (diversity)	TB	,909	37	,005
	RePro	,933	44	,013
Number_of_principles (diversity)	TB	,921	37	,012
	RePro	,912	44	,003
Number_of_high_quality_ideas (quality)	TB	,932	37	,025
	RePro	,859	44	,000
Number_of_original_ideas (originality)	TB	,883	37	,001
	RePro	,927	44	,008
Number_of_high_quality_original_ideas (originality)	TB	,730	37	,000
	RePro	,869	44	,000
Satisfaction_with_the_technique	TB	,932	37	,025
	RePro	,853	44	,000

Figure E.2.1. Tests of normality Experiment 1.

Tests of Normality (Experiment 2)

Condition		Shapiro-Wilk Statistic	df	Sig.
Number_of_unique_ideas (productivity)	TB	,967	31	,447
	RePro	,970	37	,416
Number_of_categories (diversity)	TB	,897	31	,006
	RePro	,908	37	,005
Number_of_principles (diversity)	TB	,950	31	,158
	RePro	,962	37	,233
Number_of_high_quality_ideas (quality)	TB	,950	31	,152
	RePro	,936	37	,035
Number_of_original_ideas (originality)	TB	,939	31	,077
	RePro	,894	37	,002
Number_of_high_quality_original_ideas (originality)	TB	,865	31	,001
	RePro	,854	37	,000
Satisfaction_with_the_technique	TB	,894	31	,005
	RePro	,869	37	,000

Figure E.2.2. Tests of normality Experiment 2.

In experiment 2, the normality assumption was not violated for *productivity* and *principle-diversity*. In order to determine whether we had to run an independent t-test *with* or *without* Welch's correction for these response variables, we also had to evaluate the homogeneity of variances assumption. The Levene's statistic was used for this purpose. The results of these tests are shown in Figure E.2.3.

Test of Homogeneity of Variances (Experiment 2)

	Levene Statistic	df1	df2	Sig.
Number_of_unique_ideas (productivity)	,062	1	66	,803
Number_of_principles (diversity)	7,550	1	66	,008

Figure E.2.3. Tests homogeneity of variances Experiment 2.

In Table E.2.1, we outline the selected hypothesis testing procedures based on the test results presented above.

Outcome measure	Experiment 1			Experiment 2		
	Normality assumption	**Homogeneity of variances assumption**	**Hypothesis testing procedure**	**Normality assumption**	**Homogeneity of variances assumption**	**Hypothesis testing procedure**
Number_of_unique_ideas (productivity)	Violated	N/A	Mann-Whitney U-test	Not violated	Not violated	Independent t-test
Number_of_ categories (diversity)	Violated	N/A	Mann-Whitney U-test	Violated	N/A	Mann-Whitney U-test
Number_of_ principles (diversity)	Violated	N/A	Mann-Whitney U-test	Not violated	Violated	Welch t-test
Number_of_high_ quality_ideas (quality)	Violated	N/A	Mann-Whitney U-test	Violated	N/A	Mann-Whitney U-test
Number_of_original_ideas (originality)	Violated	N/A	Mann-Whitney U-test	Violated	N/A	Mann-Whitney U-test
Number_of_ high_quality_ original_ideas (originality)	Violated	N/A	Mann-Whitney U-test	Violated	N/A	Mann-Whitney U-test
Satisfaction_with_ the_technique	Violated	N/A	Mann-Whitney U-test	Violated	N/A	Mann-Whitney U-test

Table E.2.1. Selected hypothesis testing procedures.

Appendix E.3

Results evaluation of follow-up test assumptions lab experiments Chapter 6

In this appendix, we outline the results of the tests that were used to check the *normality* and *homogeneity of variances assumption* with regard to all response variables in the three post-hoc groups. Based on these results, we determined the test that had to be performed for follow-up testing.

Figure E.3.1 and E.3.2 provide the normality test results for the response variables in experiment 1 and 2 respectively.

Tests of Normality (Experiment 1)

Usage_Style_Technique_ARC_based		Shapiro-Wilk Statistic	df	Sig.
Number_of_unique_ideas (productivity)	TB	,960	37	,203
	RePro_PC	,958	31	,254
	RePro_OC	,927	13	,310
Number_of_categories (diversity)	TB	,909	37	,005
	RePro_PC	,935	31	,058
	RePro_OC	,917	13	,227
Number_of_principles (diversity)	TB	,921	37	,012
	RePro_PC	,967	31	,430
	RePro_OC	,945	13	,521
Number_of_high_quality_ideas (quality)	TB	,932	37	,025
	RePro_PC	,906	31	,010
	RePro_OC	,948	13	,563
Number_of_original_ideas (originality)	TB	,883	37	,001
	RePro_PC	,848	31	,000
	RePro_OC	,953	13	,647
Number_of_high_quality_original_ideas (originality)	TB	,730	37	,000
	RePro_PC	,818	31	,000
	RePro_OC	,954	13	,663
Satisfaction_with_the_technique	TB	,932	37	,025
	RePro_PC	,857	31	,001
	RePro_OC	,869	13	,051

Figure E.3.1. Tests of normality Experiment 1.

Tests of Normality (Experiment 2)

Usage_Style_Technique_ARC_based		Shapiro-Wilk Statistic	df	Sig.
Number_of_unique_ideas (productivity)	TB	,967	31	,447
	RePro_PC	,973	17	,876
	RePro_OC	,938	20	,220
Number_of_categories (diversity)	TB	,897	31	,006
	RePro_PC	,914	17	,118
	RePro_OC	,897	20	,037
Number_of_principles (diversity)	TB	,950	31	,158
	RePro_PC	,966	17	,750
	RePro_OC	,928	20	,143
Number_of_high_quality_ideas (quality)	TB	,950	31	,152
	RePro_PC	,917	17	,132
	RePro_OC	,945	20	,294
Number_of_original_ideas (originality)	TB	,939	31	,077
	RePro_PC	,966	17	,736
	RePro_OC	,900	20	,042
Number_of_high_quality_original_ideas (originality)	TB	,865	31	,001
	RePro_PC	,913	17	,110
	RePro_OC	,887	20	,024
Satisfaction_with_the_technique	TB	,894	31	,005
	RePro_PC	,851	17	,011
	RePro_OC	,881	20	,018

Figure E.3.2. Tests of normality Experiment 2.

In experiment 1 and 2, the normality assumption was not violated for several response variables. In order to determine whether we had to run a Welch ANOVA or regular One-way ANOVA, we also had to evaluate the homogeneity of variances assumption for these variables. The Levene's statistic was used for this purpose. The results of these tests for experiment 1 and 2 are shown in Figure E.3.3. and E.3.4 respectively.

Test of Homogeneity of Variances (Experiment 1)

	Levene Statistic	df1	df2	Sig.
Number_of_unique_ideas (productivity)	11,875	2	78	,000

Figure E.3.3. Tests homogeneity of variances Experiment 1.

Test of Homogeneity of Variances (Experiment 2)

	Levene Statistic	df1	df2	Sig.
Number_of_unique_ideas (productivity)	,035	2	65	,966
Number_of_principles (diversity)	3,106	2	65	,051
Number_of_high_quality_ideas (quality)	1,784	2	65	,176
Number_of_original_ideas (originality)	1,901	2	65	,158

Figure E.3.4. Tests homogeneity of variances Experiment 2.

In Table E.3.1, we outline the selected follow-up testing procedures based on the test results presented above.

Outcome measure	**Experiment 1**			**Experiment 2**		
	Normality assumption	**Homogeneity of variances assumption**	**Follow-up testing procedure**	**Normality assumption**	**Homogeneity of variances assumption**	**Follow-up testing procedure**
Number_of_unique_ideas (productivity)	Not violated	Violated	Welch ANOVA	Not violated	Not violated	One-way ANOVA
Number_of_ categories (diversity)	Violated	N/A	Kruskal-Wallis test	Violated	N/A	Kruskal-Wallis test
Number_of_ principles (diversity)	Violated	N/A	Kruskal-Wallis test	Not violated	Not violated	One-way ANOVA
Number_of_high_ quality_ideas (quality)	Violated	N/A	Kruskal-Wallis test	Not violated	Not violated	One-way ANOVA
Number_of_original_ideas (originality)	Violated	N/A	Kruskal-Wallis test	Not violated	Not violated	One-way ANOVA
Number_of_ high_quality_ original_ideas (originality)	Violated	N/A	Kruskal-Wallis test	Violated	N/A	Kruskal-Wallis test
Satisfaction_with_ the_technique	Violated	N/A	Kruskal-Wallis test	Violated	N/A	Kruskal-Wallis test

Table E.3.1. Selected hypothesis testing procedures.

Beta

Research School for Operations
Management and Logistics

Eindhoven University of Technology
Department of Industrial Engineering & Innovation Sciences

About the author: Rob Vanwersch received a BSc degree (cum laude) in Industrial Engineering & Management Sciences at Eindhoven University of Technology in 2005 and a MSc degree (cum laude) in Operations Management & Logistics at the same university in 2007. After finishing his studies, Rob started working at Maastricht University Medical Center. In 2010, he received a grant from Maastricht UMC for a six-year part-time PhD project on rethinking care processes. He conducted his PhD project within the group of Information Systems of the Department of Industrial Engineering & Innovation Sciences at Eindhoven University of Technology. The results of his PhD project are presented in this dissertation.

Abstract: Many healthcare organizations are being challenged to cure more people with fewer resources, while satisfying strict quality and safety regulations. The redesign of care processes has become one of the key mechanisms for coping with this challenge. Care processes typically include consultations, diagnostic tests, and treatments, as well as supporting steps, such as scheduling. A typical redesign project that targets these processes consists of describing the as-is process, conducting an analysis of the as-is to identify process weaknesses, generating process improvement ideas (i.e. rethinking the process), and implementing the new process. Whereas redesign teams often spend much time describing and analyzing the as-is situation systematically, process improvement ideas are typically generated in one or a few workshops using a highly intuitive approach. These sessions are often chaired by an external consultant who frequently raises the question: "Does anybody have an idea?" Such a highly intuitive approach does not include a safeguard to guarantee a systematic and complete exploration of the full range of redesign options. Consequently, the improvement potential of many redesign projects is not fulfilled. This leads us to ask the question: "Does anybody have an idea regarding a better approach to rethinking care processes?" In the first part of this research endeavor, we investigated the status-quo regarding methodological support for rethinking care processes. In this way, we gained insights into potential alternatives for the often-applied, highly intuitive approach. In the second part of this research endeavor, we focused on developing and evaluating a new technique for rethinking care processes. This technique, i.e. the Rethinking of Processes (RePro) technique, guides practitioners in applying 46 categorized process improvement principles. Lab experiments were conducted to compare the performance of the RePro technique and traditional brainstorming on several outcome measures, such as the diversity and the number of high-quality ideas generated. The experiments' results confirm the potential of using the RePro technique for rethinking care processes, but also suggest that the way the technique is used strongly affects its performance.