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Implementing requirements engineering processes throughout organizations: success factors and challenges

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Abstract

This paper aims at identifying critical factors affecting organization-wide implementation of requirements engineering (RE) processes. The paper is based on a broad literature review and three longitudinal case studies that were carried out using an action research method. The results indicate that RE process implementation is a demanding undertaking, and its success greatly depends on such human factors as motivation, commitment and enthusiasm. Therefore, it is essential that the RE process is useful for its individual users. Furthermore, the results indicate that organizations can gain benefits from RE by defining a simple RE process, by focusing on a small set of RE practices, and by supporting the systematic usage of these practices.

Keywords: Requirements engineering; Process improvement; Case study; Action research

1. Introduction

In system engineering, requirements engineering (RE) is the science and discipline concerned with analyzing and documenting requirements [42]. In other words, RE means that requirements for a system are defined, managed and tested systematically. The purpose of RE is to ensure that a product development team builds a system that satisfies customer and user needs.

From the perspective of software engineering (SE), RE is the first activity of the software process, and it is intended to establish what services are required from the system and the constraints on the system's operation and development [38]. RE is a particularly critical stage of the software process as errors at the stage inevitably lead to later problems in the system design and implementation [38]. Davies compiled the results of three empirical studies, indicating that it may be up to 200 times more expensive to detect and repair errors in the maintenance stage, compared to detecting and repairing them during the RE phase [11].

Many organizations are interested in improving their RE practices and defining RE processes, because of their confidence that RE can be the key to developing successful systems. Kotonya and Sommerville define a RE process as a structured set of activities that are followed to derive, validate, and maintain a systems requirements document [29]. The purpose of a RE process is to help people to get an overview of RE, and support them in applying good RE practices.

However, implementing RE processes throughout the organization, and convincing people to apply RE practices in high-pressure projects can be a considerable challenge. For example, Wiegers points out that improving an organization's RE processes is not trivial, and haphazard approaches to process improvement do not often lead to sustainable success [47]. One of the lessons learned from software process improvement is the challenge of coping with people's resistance to change (e.g. [9,12,30,48]). Furthermore, according to Kaindl et al., it is clearly difficult to introduce results from RE research into mainstream practice, and successful technology transfer will depend on two-way collaborations between researchers and practitioners [25].

To examine the factors that influence the success of the RE process implementation, we conducted a detailed

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literature review and analyzed experiences gained from three Finnish organizations. These organizations started to introduce RE into their product development by defining a RE process model and a set of RE practices to be used in projects. This paper describes lessons learned from these case organizations. The lessons are based on a longitudinal study that was carried out using an action research method [2,40]. The long-term view and close involvement with industrial projects allowed the researchers to study issues related to RE process implementation in depth and from the perspective of practice.

This paper complements our previous research work [26,27] that focused on the early stages of RE process improvement. The experience report [26] describes the lessons learned in two Finnish organizations at the beginning of the improvement projects. The main lesson learned was that introducing RE can require cultural change [26]. The second paper [27] describes the factors that support, and those that prevent, the success of cultural change. After these two papers, we continued research work and here, we report the findings of the later stages of RE process improvement focusing on the organization-wide implementation of RE practices.

The paper is structured as follows. Section 2 reviews the success factors for process improvement found in the RE and SE literature. Then we describe the research approach, research method and case organizations of the study. The findings and the lessons learned from these three cases are explained in Section 4, and are discussed in Section 5. Finally, the paper concludes by presenting the contributions of the study and pinpointing challenges for future research.

2. Key factors for process improvement

This section summarizes the factors found in both the RE and SE literature to be key to process improvement. The literature review focus on the case studies of the RE process and the lessons learned from successful software process improvement. The results of the review form the basis of this study.

The literature review was performed twice. The first review was conducted prior to the empiric part of this study, providing a list of possible success factors that was used as a basis of data gathering. The second was performed after the analysis of the empiric data with the purpose of deepening our understanding of the process improvement literature and extending the first review by including new references.

The second review was detailed and conducted according to the recommendations of Webster and Watson [45]. First, we analyzed each reference and recorded the lessons learned and the explicitly reported success factors derived from each of them. In addition, we searched and recorded important issues related to process improvement. Finally, we analyzed all the recorded items, and clustered them around the identified key concepts. These key concepts are presented in the following two subsections.

We report the review results of the RE process and software process literature separately. This separation allows us to compare commonalities and differences of the results. The comparison of the key factors is presented in Section 2.3.

2.1. Factors found in the RE literature

Even though research on RE has been active throughout the 1990's, there are not many studies concerning RE process improvement. We found eight papers [6,7,10,19,21,26,27,36] that deal with issues relating to the success of RE process improvement. In addition to these eight papers, we also used as reference sources two RE books [37,47] that offer guidance on process improvement. The following concepts summarize the most frequently identified factors that affect the success of RE process improvement. The concepts are presented in the order of the number of references to them found in the studied RE literature.

User involvement [7,10,19,21,26,37]. One of the main factors contributing to the institutionalization of a process is the involvement of future process users and management in development of the process from the very beginning [7]. User involvement is critical for two reasons. First, it helps to develop a process that is useful to the people that have to execute this process [7,10,26]. Second, involvement increases the acceptance of the developed process [7]. Several authors also point out that RE process improvement should be a team effort (e.g. [10,19,26,37]).

Benefits of the RE process [6,7,10,19,21,37]. The studied RE literature stresses the significance of benefits for people involved in RE processes. For example, Sommerville and Sawyer argue that one should always try to introduce techniques where everyone involved (not just managers) sees some benefits [37]. Further, Hutchings and Knox report that the root cause of the difficulty of maintaining the committed participation of the marketing function in the requirements management process of Digital Equipment Corporation was that the marketing people could not see the value of their participation in terms of the deliverables of their function [19].

Cultural change [7,19,21,26,27]. The results of four case studies [7,19,21,26] show that the introduction of RE involves not just a change of process or technology, but also a change of culture. Such cultural change means two things. First, product development personnel need to understand the importance of customer and user requirements and, secondly, they must commit to defining and managing requirements systematically [26]. The results of the case studies [19,21,27] also indicate that the cultural change towards systematic customer requirements management is challenging.

Continuous RE process improvement [6,7,10,37,47]. Calvo-Manzano Villalón et al. encourage companies to

manage process evolution by expert support and the application of metrics and corrective actions [6]. Similarly, Sommerville and Sawyer point out that organizations need to establish procedures to collect feedback on improvements and ensure that action is taken in response to this feedback in order to correct any identified problem [37].

Evolutionary RE process improvement [19,26,37,47]. Sommerville and Sawyer argue that it is not realistic to expect organizations to invest a lot of time and money in improvements whose value is difficult to assess [37]. Therefore, they recommend organizations to introduce small-scale improvements with a high benefit/cost ratio before expensive new techniques. Wiegers aligns with these statements and argues that instead of aiming for perfection, it is important to develop a few improved procedures and to get started with implementation [47].

Pilot projects [6,7,19,37]. According to Claus et al., one of the main success factors of process definitions is that at least one software development project is involved from the start of the process improvement initiative and applies the new processes [7]. This ensures that the defined processes are feasible and actually benefit development projects rather than slow them down [7]. Sommerville and Sawyer also point out that it is important to introduce process changes in pilot projects in order to find out the advantages and disadvantages of the change [37].

Training and education [6,7,10,21]. Damian et al. report that once the RE process was revised, training and leadership was essential for change management [10]. According to them, this aspect is often overlooked and becomes a cause of failure of organizational change efforts. In addition, Jacobs reports that training only a few persons and hoping in the multiplier-effect is likely to fail [21]. He points out that all parties to be involved in RE have therefore to participate in adequate training.

Simplicity of the RE process [7,19,27,36]. According to Salo and Käkölä, the presence of multiple stakeholders from several functional organizations, some of whom participate in requirements processes in a minor role, implies that these processes, methods, and tools should be as simple as possible [36]. In addition, Hutchings and Knox report that the Digital Equipment Corporation had a detailed nine-step requirements management process that focused primarily on engineering deliverables such as a requirements document and a functional specification [19]. In order to support the work of cross-functional teams and marketing personnel's participation in requirements management, marketing deliverables were included as outputs of the process, the original nine steps were hidden in the background of the process description and the requirements management process was simplified into three broad phases [19].

2.2. Factors found in the SE literature

Software process research grew up during the 1980's to address the increasing complexity and criticality of software development activities [13], and it has a longer tradition than RE process research. Therefore, software process literature is more extensive than RE process literature, and offers knowledge valuable to the RE research community. This part of the review is based on 14 case studies [3–5,12,14,17,22–24,28,31,35,41,46] and three SPI books [16,33,48]. In addition, we include two papers [8,9] that summarize the process improvement experience gained over several years by three researchers. The following eight concepts summarize the factors most frequently identified as critical to software process improvement.

User involvement [4,8,9,12,14,23,24,28,30,31,33,41,46,48]. User involvement is a widely reported success factor in the studied software process literature. For example, Basili et al. report that direct input from developers is a key factor in software process change [4], while Diaz and Sligo point out that practitioners, not outside process experts, should define the processes in question [12]. Similarly, Curtis argues that a characteristic of successful improvement projects is that the improvements are designed by those who must adopt them [9]. Moreover, McFeeley recommends that the improvement team should include users of the process, suppliers to the process, and receivers of the finished product [30].

Management commitment and support [5,8,9,12,14,17,24,28,30,31,33,46,48]. The studied software process literature strongly indicates that management commitment and support are critical to the success of improvement efforts. According to Diaz and Sligo, management commitment is required from all levels [12]. Several authors state the importance of senior management support, e.g. [5,9,12,24]. Middle management resistance can also threaten the success of process changes [8,9,48]. In addition, Diaz and Sligo report that commitment from upper management will not be enough unless individual project leaders are also determined to succeed [12]. However, commitment does not simply mean giving approval [31]. It means, for example, providing visible active support and encouragement [31]. Management can support process improvement work by providing it with funding, staff and time [12,24,48].

Measurement [3–5,8,14,16,24,28,30,31,35,41,48]. Measurement of improvement efforts is widely covered in the software process literature. According to Humphrey, sustained progress is not possible until the process is under statistical control [16]. In addition, several other authors state the importance of measurement to successful process improvement (e.g. [5,14,31,48]). On the other hand, some authors report that it is difficult to quantify the impact of process improvement efforts (e.g. [8,28,46]). In addition, Humphrey points out that measurements are expensive, while overzealous measuring can degrade the process that is tried to be improved [16].

Process improvement goals [8,12,14,30,31,33,35,41,48]. A number of authors state explicitly that it is essential to align process improvement goals with the business goals of the organization [8,30,31,33,48]. However, Kautz et al.

report that instead of the organization's vision and business objectives, more concrete structural and cultural elements were the shaping forces of the software process improvement initiative in a Danish software company [28]. Structurally, the organization was small with a relatively flat hierarchy and short communication ways, while culturally, it was an open, energetic, and action-oriented enterprise geared towards fast results [28].

Resistance to change [8,9,12,16,22,28,30,35,48]. Several authors state that being able to deal with people's resistance to change is critical to the success of process improvement initiatives [12,30,48]. Moreover, several other authors report resistance to change to be a problem (e.g. [8,9,22, 35]). According to McFeeley, resistance to change is directly correlated to the total amount of change required of individuals [30]. Two other reasons for rejecting changes are that change initiatives proceed too quickly [46,48] or they are introduced too frequently [22].

Training and education [14,16,24,28,31,33,35,46,48]. According to Humphrey, Kautz el al., and O'Hara, training is one of the key points in software process improvement [16,28,31]. In addition, Zahran argues that a process that is not consistently trained will be ineffective [48]. He especially emphasizes the importance of the introduction training given to new staff who join the organization or the project from outside.

Continuous process improvement [4,8,14,24,33,48]. Zahran states that continuous process improvement is a critical success factor for software process improvement [48]. In addition, Johnson reports that continuous process improvement is believed to be a requirement in maintaining the competitiveness of software organizations [24]. Continuous process improvement relates closely to evolutionary process improvement. For example, Paulk argues that continuous process improvement is based on many small, evolutionary steps rather than revolutionary innovations [33].

Evolutionary process improvement [3,8,16,33,46,48]. An evolutionary improvement approach has not been mentioned explicitly as a success factor for process improvement in the studied SE literature. However, Zahran states that prioritization of improvement actions is a critical factor in the successful implementation of software process improvement. [48]. In addition, several authors recommend improvement actions to be performed in small steps (e.g. [8, 16,33]).

2.3. Comparison of the factors found in the RE and SE literature

According to the studied literature, there are four key factors that are common to both RE and software process improvement. First, there is widespread consensus both in the RE and SE literature that user involvement is one of the key success factors in process improvement. Secondly, researchers in both fields also emphasize the importance of training. The third and fourth factors relate to process improvement approaches. According to the studied RE and SE literature, it is essential that process improvement is both evolutionary and continuous. The evolutionary approach emphasizes small improvement steps, while the continuous approach stresses active collection of feedback on improvements and corrective actions based on the feedback.

The studied SE literature provides strong empirical evidence that management support is one of the key success factors for software process improvement. Seven out of the 14 case studies report explicitly management commitment and support to be critical for successful improvement initiatives. On the other hand, only two out of the eight RE case studies point out the importance of management support. In addition, neither of the two RE books that were included in our literature review emphasize the role of management in RE process improvement. We could not find any explanation in the studied RE literature why management support is not considered as a critical factor for RE process improvement.

Another significant difference between the success factors found in the RE literature and the SE literature relates to measurement. The studied SE literature strongly emphasizes the importance of the measurement of process improvement efforts, whereas the studied RE literature discusses the difficulties of quantifying the effect of the RE process changes (e.g. [6,21,37]). A possible explanation for this difference is that the software process case studies of the review describe improvement experiences that are mainly gained from large organizations (e.g. [3–5,14,17]) These large organizations have been able to implement and invest in long-term measurement programs, despite measurement being expensive [16] and requiring a rigorous process and professional staff [5].

The studied SE literature emphasizes the importance of aligning process improvement goals with the business goals of the organization, whereas the RE literature points out tangible and short-term benefits for RE process users. Further, several RE case studies recommend testing RE processes in pilot projects before organization-wide implementation, whereas piloting was considered as a key factor only in three SE references [5,16,31]. In addition, the studied RE literature suggest that organizations should implement a simple RE process, whereas none of the references included in our SE literature review recommends a simple software process.

In the studied SE literature, resistance to change is a widely recognized problem and is considered to be one of the biggest challenges in software process improvement. In the RE literature, this problem is discussed in three case studies [7,10,19], and only one of them [19] reports that overcoming resistance to change is critical for RE process improvement success. We find this difference interesting. It raises the question, what are the factors that support the willingness of personnel to adopt a process change, or in

other words, what are the factors that make personnel resist a process change?

3. Research methodology

The experience drawn on in this research comes from work with three industrial partners of the QURE (Quality through Requirements) project. The research goal of the QURE was to investigate how organizations can develop products that better satisfy user and customer needs.

3.1. Context and research scope

All the three case organizations were product development units of medium-size or large companies (Table 1). The companies focus mainly on market-driven products, but, occasionally, they develop customer-specific systems. Company B and C develop interactive systems, and the products of Company A have both real-time embedded and interactive components.

We defined a simple process improvement procedure (Fig. 1) to guide the systematic RE process improvement of the case organizations. The procedure combines tasks from the IDEAL model [30] and the ISO/IEC 15504 standard [20]. The first activity of the procedure is to analyze the current state of the existing RE processes and to identify their strengths and weaknesses. Based on the assessment results, the organization develops a new RE process that solves the existing problems. The new practices must also be piloted to ensure the practicality and usefulness of the developed RE process. After piloting, the new process is systematically deployed throughout the organization. The purpose of the systematic implementation is that all process users are aware of the new practices and can apply them in product development projects. The last step of the improvement cycle is to collect feedback about the RE process and to evaluate the impact of the improvement efforts.

The process improvement procedure in Fig. 1 does not show all the iterations. In practice, there were no distinct boundaries between the activities. Development and piloting in particular were interleaved, and there was a great deal of iteration between these two activities.

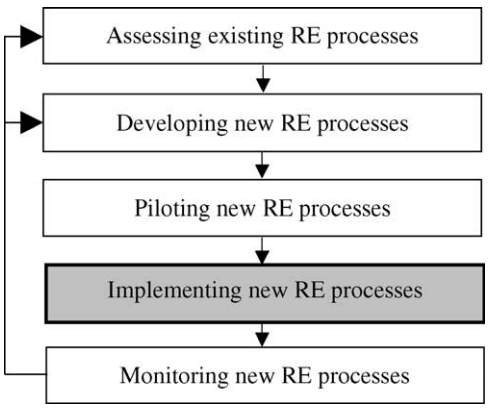

Fig. 1. Process improvement procedure of the study.

Even though the focus of this study was on the implementation activity (Fig. 1), we did not concentrate exclusively on it. The aim of the study was to examine the critical factors for successful implementation during all the activities of the process improvement procedure. In addition, the study is based on longitudinal research (Table 2). The long-term view allowed the researchers to study issues related to RE process implementation in depth.

3.2. Research approach, method and procedure

This study was carried out using a qualitative research approach and an action research method. According to Avison et al., a particular strength of qualitative methods is their value in explaining what goes on in organizations, and action research can address complex real-life problems and immediate concerns [2]. In addition, qualitative methods permit the evaluator to study selected issues in depth and detail [32]. Also, Colin Potts suggests an 'industry-as-laboratory' research approach where researchers identify problems through close involvement with industrial projects, and create and evaluate solutions in an almost indivisible research activity [34]. According to Potts, this lets researchers emphasize what people actually do or can do in practice, rather than what is possible in principle.

According to Avison et al., action research is an iterative process involving researchers and practitioners acting together on a particular cycle of activities, including problem diagnosis, action intervention, and reflective

Table 1
Description of the participating companies

Company	Number of employees	Application domain
A	23 600	Transportation systems for buildings
B	1200	Measurement systems for meteorology, environmental sciences and traffic safety
C	450	Information management systems for building, public infra and energy distribution designers

Table 2
Duration of the research co-operation with the case organizations

R&D organization	Research co-operation	
	Period	Duration
A	Feb 1999–Sep 2002	44 months
B	Feb 1999–Sep 2002	44 months
C	Jun 2000–Nov 2002	30 months

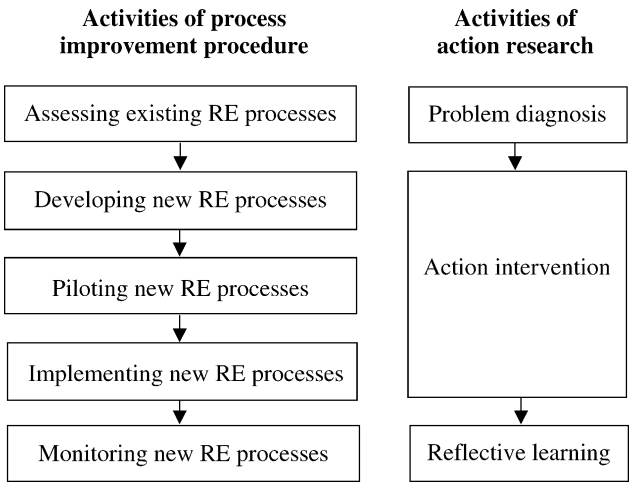

Fig. 2. Process improvement procedure and action research activities.

learning [2]. Fig. 2 shows how the process improvement procedure relates to these action research activities.

The researchers participated in all the activities of the RE process improvement procedure shown in Fig. 1. The role of the researchers was to act as facilitators assisting the case organizations to improve their RE processes. During the assessment and monitoring activities, the researchers were responsible for interviewing people, for analyzing requirements documentation and for reporting the results. During the remaining activities, the researchers were members of the process improvement teams. Their role was to provide information about RE practices and methods, and to support improvement actions. They were also responsible for observing process improvement activities and capturing potential lessons learned.

A preliminary understanding of the issues related to RE process implementation was gained through a literature review. The literature review led to a list of possible success factors. These success factors were used as the basis for data gathering and analysis.

The findings of the study are based on the data collected through observations, informal conversations, formal interviews, and analysis of both RE process documentation and requirements documents (Table 3). The purpose of the interviews and document analysis was to gain information on how practitioners defined and managed requirements in practice and what the strengths and weaknesses of the existing RE practices were. Participant observation and informal conversations provided detailed information on how the process improvement activities were performed in practice and how real product development projects applied new RE practices.

Table 3
Data collection techniques in the action research procedure ($n1$ = number of interviews, $n2$ = number of interviewees)

Research activity	Data collection techniques
Problem diagnosis	Structured interviews ($n1 = 10$, $n2 = 13$) semi-structured interviews ($n1 = 11$, $n2 = 11$) document analysis
Action intervention	Observations, informal conversations, document analysis
Reflective learning	Structured interviews ($n1 = 3$, $n2 = 12$) semi-structured interviews ($n1 = 16$, $n2 = 23$) informal conversations, document analysis

The researchers interviewed project managers, product managers, domain experts, usability experts, product development managers, product development engineers, and persons who were responsible for coordinating RE process improvement. The total number of interviews was 40, nine of which were group interviews. The total number of different informants was 47. Two persons were interviewed three times, and seven persons twice during the RE process improvement.

The success factors found in the RE and software process literature were used to guide the data collection. However, the data gathering was not confined to these factors; the researchers also aimed at identifying other possible factors that affect organization-wide adoption of RE practices. Data was analyzed using both a top–down and a bottom–up approach. In the top–down analysis, we used the success factors found in the literature to identify the issues related to RE process implementation in the case organizations. In the bottom–up approach, we wrote summaries of the implementation-related issues for each case organization. After that, we clustered the issues into high-level categories.

3.3. Internal validity of the findings

In this paper, we use the term ‘finding’ to refer to observations and other experience gained from a single case. Here, we address the internal validity of the findings from four perspectives. First, we used the triangulation of data sources and data collection techniques to improve the internal validity of the findings within each case organization. Our study intermixed interviewing, document analysis, informal conversations and observation. By combining different data collection techniques, we were able to cross-check findings and gain a holistic view of RE process implementation in the individual case organization.

Secondly, to increase the internal validity of the findings, a rather large number of informants were selected using a typical case sampling strategy [32]. We interviewed 18 persons from Organization A, 17 persons from Organization B, and 12 persons from Organization C. In each case organization, the interviewees were selected with the co-operation of the key informant who knew the employees of the organization. These key informants helped identify persons that had recently defined requirements for typical product development projects. Most of the interviewees were product managers, project managers and domain experts. In the case organizations, these persons were typically responsible for defining requirements.

Thirdly, the study was carried on in each case organization over a long period, between 2 and 3.5 years, which improved further the internal validity of the findings. The long-term view allowed us to verify the observations made at the beginning of the study and discover new issues that relate to organization-wide implementation of RE processes.

The fourth validity issue concerns investigator triangulation. Because of the limited budget and the longitudinal nature of the study, we were able to use investigator triangulation in a very restricted way. The first author of the paper designed interview questions. To avoid bias and misinterpretation of the questions, another researcher reviewed them. The first author conducted most of the 49 interviews and analyzed the collected data. To improve internal validity, the findings were discussed with another researcher who had participated in the RE process improvement work of all the case organizations.

3.4. External validity of the lesson learned

We use the term 'lesson learned' to refer to potentially generalizeable conclusions. These lessons have been derived from the meta-analysis of the findings of the individual cases. To improve the external validity of the lessons learned, this study involved three separate organizations. To make the findings comparable, we used the same research procedure, data collection techniques and interview questions in all three cases.

The case organizations were selected using a convenience sampling strategy. The organizations were the industrial partners of the Qure research project. Convenience sampling is the least desirable sampling strategy [32], and is a threat to external validity. To increase the external validity of the lessons learned, we additionally used method triangulation. A preliminary literature review was conducted before the empirical case studies, and a detailed review after the empirical studies. This allowed us to compare the empirical observations and lessons described in the existing process improvement literature with our results, and vice versa.

Patton points out that there are advantages and disadvantages to reviewing the literature before, during, or after fieldwork—or on a continual basis throughout the study [32]. The results of the literature review may bias the researcher's thinking and lead to 'fishing'. On the other hand, the results of the fieldwork may affect what data the researcher discovers from the literature, in other words may similarly lead to fishing.

To decrease the bias between the literature reviews and empirical part of the study, the researchers adopted a stance of neutrality with regard to the phenomenon under study, i.e. factors affecting the organization-wide implementation of RE processes. Neutrality means that the investigator does not set out to prove a particular perspective, or manipulate the data to arrive at predisposed truths [32]. Rather, the investigator's commitment is to understand the world as it is, to be true to complexities and multiple perspectives as they emerge, and to be balanced in reporting both confirmatory and disconfirming evidence [32].

4. Findings and lessons learned

The purpose of this study was to understand how a RE process can be implemented successfully throughout an organization. In Section 4.1, we describe how the case organizations succeeded in RE process improvement. Section 4.2 explains the factors that supported the organization-wide implementation of the RE process, and Section 4.3 describes the most common challenges that appeared in the case organizations. These challenges can become pitfalls in the successful adoption of the RE practices if the risks related to them are not tackled and eliminated.

4.1. Process maturity of the case organizations

The maturity level of the RE processes of the case organizations was assessed using the REAIMS maturity model [37]. RE process maturity is the extent to which an organization has a defined RE process based on good RE practices [29]. The REAIMS maturity model has three levels: initial, repeatable, and defined [34]. The model includes 66 RE practices, which have been classified into three categories: basic, intermediate and advanced practices [37]. The maturity level of the RE process is calculated by combining the numerical scores for each practice. The numerical score describes how widely and systematically the RE practice is used in the organization. According to the developers of the REAIMS maturity model, the RE maturity of almost all organizations is at the initial level, and very few organizations have an explicitly-defined and standardized RE process [37].

The RE process assessment was performed twice in the case organizations. The researchers evaluated the state of the RE practices based on analysis of requirements documentation and in-depth interviews. The total number of informants that participated in in-depth interviews was 27, which forms a part of the 47 informants mentioned in Section 3.2. All these persons had recently defined requirements for typical product development projects. Thirteen persons from Organization A, eight persons from Organization B, and six persons from Organization C participated in the in-depth interviews. Most of the informants were product managers, projects managers and domain experts. These roles represented typical persons that are responsible for defining requirements.

The researchers used the same strict criteria in all the assessments to ensure comparability of the results. The first assessment results from 1999 to 2000 show that the RE processes of all the case organizations were at the initial

Table 4
Maturity level of the RE process of the case organizations based on the REAIMS model

	Organization A		Organization B		Organization C	
	1999	2002	1999	2002	2000	2002
Maturity level of the RE process (initial when the score of the basic RE practices is less than 55, repeatable when the score of the basic RE practice is above 55)	Initial	Initial	Initial	Initial	Initial	Initial
Score of the basic RE practices (maximum 108)	19	30	14	28	15	31
Score of the intermediate and advanced RE practices (maximum 90)	10	18	6	11	10	9

level of the REAIMS model (Table 4). At that time, we found projects that had produced a good requirements document, but none of the case organizations had a documented RE process. Therefore, RE practices were dependent on individuals, and people did not have a mutual understanding of how to define and manage requirements in product development projects. The case organizations did not have a culture of defining requirements systematically from the customers' and users' point of view. Requirements were defined mainly from a technical point of view, and they described design solutions.

Even though the RE processes of the case organizations were at the initial level, the organizations have developed successful products for years. All the companies are internationally known, and have a significant market share globally. The product development organizations have experts that understand the application domain well, and these domain experts have effectively shared their knowledge with others. However, because the product development environment is changing, the case organizations started to improve their RE processes, rather than continue to rely on the tacit knowledge of the domain experts.

The assessment results for 2002 show that RE processes maturity was approaching the repeatable level in all the case organizations. All the case organizations had documented their RE processes. The interviews and informal conversations also showed that awareness of RE among both staff and management had also increased. The score of the basic RE practices had risen in all the case organizations (Table 4), and a small set of the RE practices was either systematically or normally used (Table 5).

One promising sign of the successful implementation was the feedback received from the practitioners that had applied the new RE practices in real product development projects. Nineteen of the 22 interviewees found RE very useful, and the remaining three informants considered RE useful. The interviewees mentioned the following benefits:

- Without knowing customer needs, it is impossible to develop a good product.
- Requirements describe the collectively accepted objectives.
- Requirements improve the commitment and motivation of the project members.
- Requirements improve communication outwards from the project (managers and users).
- Requirements are the basis for systematic product development and project planning.

We regard the RE process to be implemented successfully when people have internalized the usefulness of RE, and the RE practices are in general use across the entire organization. According to these criteria, progress has taken place in all the case organizations. The RE processes were more systematic and the RE practices were used more widely in 2002 than in 1999 and 2000. However, the culture of defining customer and user requirements systematically is still young in the case organizations. Therefore, the organizations must pay special attention to ensuring that the RE process will affect the entire organization permanently and that the new RE practices will be applied also in future.

4.2. Success factors

In this section, we describe seven factors that supported the organization-wide implementation of the RE processes.

Table 5
Usage scope of the 66 RE practices of the REAIMS model

	Organization A		Organization B		Organization C	
	1999	2002	1999	2002	2000	2002
Number of systematically used practices	0	0	0	2	0	1
Number of normally used practices	1	13	0	6	2	5
Number of sometimes used practices	27	22	20	21	21	27
Number of never used practices	38	31	46	37	36	14
Number of irrelevant practices	0	0	0	0	9	9

These factors are (1) motivation, commitment and enthusiasm of personnel, (2) usefulness of the RE process, (3) practicality of the RE process, (4) training, (5) support, (6) implementation strategy, and (7) improvement activities.

4.2.1. Motivation, commitment and enthusiasm of personnel

One of the main findings was that the change in behavior had to happen first at the individual level, then at the project level, and finally at the organizational level. Therefore, a key issue in the RE process improvement was to emphasize that the purpose of the new process is to help practitioners to do their job. When the new RE process was introduced, it was essential to respect the skills of the practitioners, and not to point out what they have done poorly in the past.

The practitioners were afraid of wasting time on doing unpractical things that do not solve any existing problem or provide any benefits. When the practitioners could see results from using the new RE practices, they became motivated to apply the practice again in the future. Enthusiasm and pride supported people's commitment to the new RE practices. For example, one project team was not at first eager to review the requirements. After the first inspection session, all the participants found the session useful, and wanted to organize more review meetings. In addition, the project manager was so satisfied with the review meetings that he decided to form a group of experts to check requirements also in future projects.

In each of the case organizations, one or two persons were convinced of the importance of defining requirements systematically. In order to make new RE practices permanent, the RE awareness needed to spread throughout product development management and personnel. First, product development personnel needed to understand what RE means and how they can benefit from the new RE practices. In addition, raising management awareness of RE was found vital. If management had not fully understood why to invest in RE and if they were not fully committed to support RE process improvement, the implementation of the new RE practices slowed down or even stopped.

The experiences in all the case organizations showed that introducing RE involved a cultural change. Such a cultural change requires that requirements are defined systematically, not only from a technical point of view, but also from the customers' and users' points of views [27]. It was challenging to make a change of behavior happen in practice because both managers and product development engineers held beliefs that prevented systematic user requirements definition [27]. For example, people assumed that users do not have any needs for new products. Therefore, instead of discovering real user needs systematically, product development engineers invented user requirements themselves. The beliefs were the most challenging obstacles to cultural change, because they also related to values and attitudes.

The lesson learned is that the change required by the RE process starts from individuals, and therefore it is vital to treat people as experts and respect their skills. If the individuals are motivated and enthusiastic in performing the new practices, it is more probably that these practices will become permanent.

4.2.2. Usefulness of the RE process

We identified three factors that affect how useful people judged the new RE process. The first factor concerns how soon people could see the benefits of the new RE practices. People were more motivated to change their way of working if they could see the results of the change in the near future. If the benefits of the new RE practices could be achieved only in the long term, people gave them up more easily. For example, one project produced a traceability matrix between the requirements and the system components during requirements definition. Most of the project members that were interviewed did not find the matrix useful because it did not help them to define requirements.

The second factor related to usefulness was for whom the new practices were beneficial. People were more motivated to change their behavior if they could see that the results of the change were likely to be useful to themselves or to other project members. If the benefits of the new RE practices could be seen only at product development or company levels, people gave them up more easily.

The third factor related to usefulness was how valuable and measurable the benefits of the new RE practices were. The managers in particular wanted to have measurable data from the new RE process. Product developers were ready to change their way of defining requirements if they had piloted the new practices and had gained even such fairly abstract benefits as better understanding of goals of the project or improved communication about the requirements. Reporting positive experiences of other projects was a good way to sell the new RE practices to project teams.

The lesson learned is that the more immediate, personal, and concrete the benefits of new RE practices are, the better are the chances that organizations will succeed in implementing them permanently throughout the organization.

4.2.3. Practicality of the RE process

All the case organizations defined a process to give an overview of RE. The main idea was to keep the RE process model simple. Because the personnel of the case organizations were not aware of RE, the simple model helped practitioners to understand the basics of the systematic requirements definition.

The experiences showed that the practitioners wanted to have RE practices that are easy to learn and use. People did not have time for long training courses because of the tight schedules of the product development projects. The practitioners were satisfied if they could understand the new RE practice, method, or technique in a day or even in half a day.

It was also important that the new RE practice did not require weeks of effort to be performed. If the practice took

weeks or months of effort, it was important that it could be performed step by step. For example, one project team decided to pilot use cases in order to improve communication between the subprojects even though they had already started designing the system. The team members almost gave up when they understood that writing all the use cases requires several months' effort. The solution was that the most critical use cases were written first, and the remaining cases later when the team had evidence of the usefulness of the use cases. After the piloting period, the project manager's comment was, 'I wish we had had these use cases at the beginning of the project'.

People also wanted to have a flexible RE process, which means that the practitioners wanted to tailor the process to the needs of their project. Practitioners pointed out that the same RE practices do not automatically suit all kinds of situations. For example, a project developing a new version of a product might need more lightweight RE practices than a project developing an entirely new product.

The lesson learned is that the simpler and easier to learn and apply the new RE process is, the more willing practitioners are to use it. In addition, practitioners want to have a flexible RE process that they can adjust according to the needs of their product development project.

4.2.4. Training

The first implementation experiences in the case organizations showed that introducing the basics of RE seem to require a day's training course. The purpose of the basic training was to describe why RE is important, to give an overview of the RE process, and to show how this process relates to the organization's product development process.

The traditional classroom style of teaching was ineffective when the objective was to integrate the RE process with daily routines. Some of the practitioners said that they were not willing to attend a course where somebody goes through all the details of the new process. The pilot projects showed that 'Just-in-Time' training combined with learning-by-doing was required to change the way in which product development teams defined requirements in practice. Hutchings et al. introduced the principle of 'Just-in-Time' training, according to which teaching must fully support the team's work and occur at the time the team needs it [16].

It was also important to train all the persons that were involved in requirements definition and management. People had communication problems and were not able to co-operate well if only the key persons were trained to use the new RE process. First, people could mean different things when they were talking about requirements. For example, a product manager used the term 'requirement' in the meaning of external properties of the system to be developed. For a project manager, the word requirement meant technical requirements. Secondly, people could have different views on how to define and manage requirements in practice, which made the co-operation difficult or caused conflicts between different stakeholders.

The lesson learned is that the traditional classroom style teaching suits training that aims at raising personnel awareness of RE. 'Just-in-Time' training is needed if the organization wants to implement the new RE practices permanently.

4.2.5. Support

The experiences in all the case organizations showed that management support for RE was vital. In the case organizations, where the support of the senior managers was concrete and visible, the implementation occurred more smoothly than in the organization where senior managers did not have time to be involved in the RE process improvement. It was also important that project managers supported people in performing the RE practices. For example, one project manager was the key reviewer of the use cases. The authors of the use cases found the manager's feedback of valuable, and it encouraged them to continue writing the use cases.

The pilot projects also indicated that the more demanding RE practices required an RE expert's support when people were performing the practices for the first time. For example, one project manager reported that she would have given up documenting the requirements if the RE expert had not helped her.

In addition to management and RE expert support, people also wanted to have document templates and practical guidelines for defining requirements. The practitioners said that they could use written instructions as a checklist when they perform the new RE practices.

The main lesson learned is that concrete and visible support from all management levels is vital for successful RE process implementation. In addition, a RE expert's assistance, a requirements document template combined with real examples, and practical guidelines support the implementation of the RE process.

4.2.6. Implementation strategy

The experiences in the case organizations indicated that the successful implementation of the new RE practices requires a systematic approach. If the implementation approach was haphazard, only some people were aware of the new RE practices, and there was a considerable risk that product development projects would give up the new practices under pressure of tight schedules. The systematic approach covers such issues as how the training and support are organized. It should also include a plan of how to collect feedback from the new RE practices and how to improve the RE processes continuously.

The success of the RE process implementation was also dependent on the magnitude of the change. In the case organizations, where the changes to the current state were small and incremental, people were more willing to apply

the new practices than in the organizations that tried to make a large change in one go.

In one case organization, people had strong attitudes against new processes. Based on their earlier experiences, the practitioners thought that the new process was merely bureaucracy and defined from a management perspective. The experiences showed that people changed their minds if they could see how the new process helped them to do their job better.

The lesson learned is that successful implementation of RE practices is based on a systematic, incremental and people-oriented strategy.

4.2.7. Improvement activities

The experiences in all the case organizations showed that it was important to use practitioners and involve representatives of all process user groups in defining the new RE process. The role of the practitioners was to bring knowledge of the existing RE practices and to ensure that the new RE process was practical and satisfied the needs of product development projects. In one case organization, representatives of one of the process user groups were too busy to attend improvement work actively. This caused subsequent problems because members of this user group felt that outsiders had defined the RE process for them, and therefore they were unwilling to use it.

The experiences in the case organizations also showed that it was important to pilot RE practices before they were implemented organization wide. Piloting demonstrated the benefits and the shortcomings of the new RE practices. It was also important to modify the new RE process based on the feedback gathered during the piloting.

The lesson learned is that it is essential to involve representatives of all process user groups in defining the new RE process. It is also important to pilot new RE practices before they are implemented organization wide.

4.2.8. Summary of the success factors

The findings of the study show that implementing the RE process throughout the organization is a complex phenomenon. Its success depends on many factors, and, furthermore, these factors are interrelated. The key factors can be grouped into further abstract categories (Fig. 3). The aim of Fig. 3 is to give a structured view of the key factors and propose their main relationships. According to Strauss and Corbin, grouping concepts into categories is important because categories have the potential to explain and predict about the phenomenon under study [39]. In addition, they emphasize the identification of the central category that represents the main theme of the research. A central category has analytic power to pull the other categories together to form an explanatory whole [39].

One of the main findings was that RE process change is bottom–up. The change of behavior needs to happen first at the individual level, and it can spread to project teams and finally to the entire organization. Therefore, we classify human factors as a central category (Fig. 3). We also suggest that these human factors can explain why people may resist a process change. For example, if people do not understand the reasons for a process change, i.e. why they have to change their way of working and what they gain from the new process, they are probably not willing to adopt it. The new process can also require new skills. If people are not offered adequate training, they can be reluctant to change their working practices.

Fig. 3 shows only a limited set of the relationships between the success factors (categories). Our study suggests that there are several other relationships between the factors. For example, if the process is simple, it is also easy to learn and apply, and then it does not require massive training and support. Human factors are also dependent on each other. First, people must be aware of the new RE process, understand its importance and how to use it. They can then

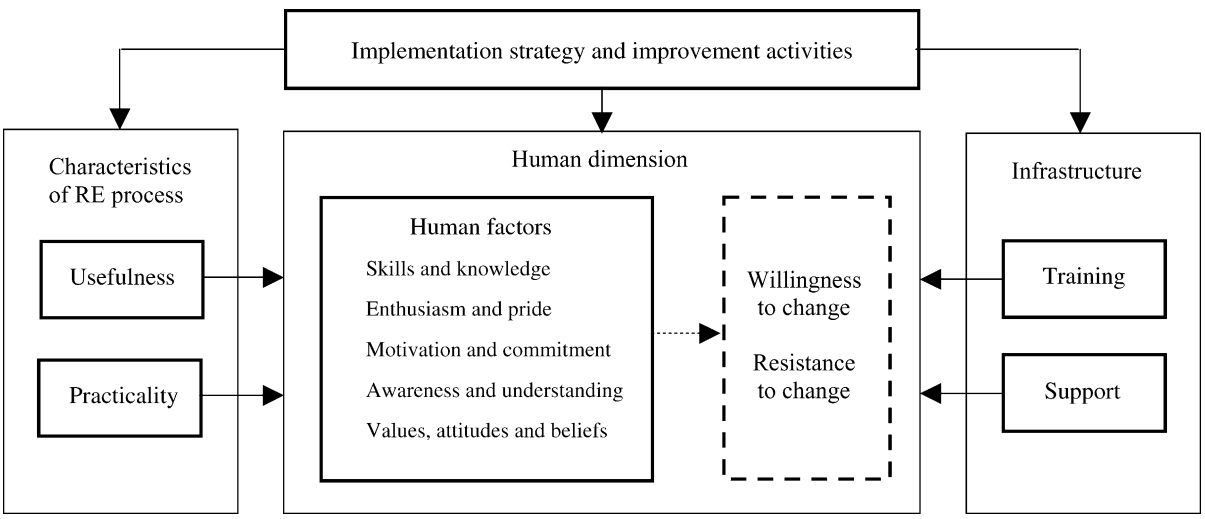

Fig. 3. Model of the factors affecting organization-wide implementation of RE processes.

become motivated and committed to performing the new RE practices. If individuals are also enthusiastic about, and proud of, a new RE process, it is more likely that they will not give it up under schedule pressure.

In addition to Fig. 3, Appendix A also summarizes the success factors. It provides the guidelines for RE process implementation from the perspective of practice. The guidelines are based on the factors found in the software process and RE process literature, and supplemented by the lessons learned from the three case organizations of this study.

4.3. Challenges

The following six sections present challenges that appeared in the case organizations. These challenges might turn out to be obstacles to the successful implementation of the RE processes if organizations do not pay special attention to them. The experiences also indicate that four of these challenges can become a success factor if organizations are able to avoid risks related to the challenges.

4.3.1. Duration of the change

The experiences in all the case organizations showed that the introduction of RE and the organization-wide implementation of the RE process take time. In particular, cultural change took place more slowly than the practitioners were prepared for. Product development personnel were so used to focusing on technical details that they had difficulties defining user requirements. The change was deeper and more time-consuming if people had beliefs and attitudes related to the systematic definition of user requirements.

The risk related to the long duration of the change is that managers may start to lose their interest because they cannot perceive the high-level benefits deriving from the RE process improvement. If the management stops emphasizing the importance of RE, product development personnel starts losing their confidence in the worth of defining requirements systematically.

The lesson learned is that organizations need to allow enough time to make the change, especially if they are just starting to introduce RE. Introducing RE appears to involve a cultural change, and therefore the organization-wide implementation of the RE process can take several years.

4.3.2. Personnel changes

Personnel changes took place in all the case organizations during the RE process improvement. For example, in one case organization, a representative of the senior management was actively involved in the project of the RE process improvement. Because of the organizational change, this manager could not continue to support the RE process improvement. In this same case organization, the manager of the process improvement project changed. The position of the new person was not strong, because she was not named formally as a project manager. The implementation of the RE process slowed down after these personnel changes.

The risk related to personnel changes is that key persons leave, and the RE process disappears with them. The lesson learned is that organizations need to have several people responsible for improving the RE process and should not rely on just one change agent or evangelist.

4.3.3. Training and support resources

'Just-in-Time' training combined with RE support was piloted in at least two product development projects in each case organization. The experiences showed that 'Just-in-Time' training and RE support require persons that have good knowledge about the RE process and practices of the organization. In addition, experience of product development and knowledge about application domain increased these persons' capability to help project teams to tailor the RE process and to apply RE practices to the needs of the projects.

The risk related to training and support resources is that organizations find 'Just-in-Time' training and RE support too expensive or too difficult to organize because all the skilled persons are tied up with product development work. Another risk is that product development teams expect the RE expert to do the requirements definition work. Therefore, the expert can become a bottleneck or in the worst case, people do not learn to apply the RE practices themselves.

The lesson learned is that 'Just-in-Time' training and RE support require skilled persons and investment. If 'Just-in-Time' training combined with RE support is well planned and organized, it can pay off and be more cost-effective than traditional classroom style of teaching and external RE courses.

4.3.4. Scope of the RE process

All the case organizations integrated the RE process with their product development process. The experiences showed that RE relates also closely to business processes as strategic planning and roadmapping. In addition, the experiences showed that sales, sales support, and marketing personnel have valuable knowledge and information for customer and user requirements definition. However, it was occasionally difficult to involve these important stakeholders in requirements definition because they could not see how to combine the RE practices with their existing duties and tasks.

The risk related to the scope of the RE process is that linking the RE process with business processes makes the change bigger, more difficult, and more time-consuming.

The lesson learned is that RE processes can concern not only product development but also such organizational units as a company's sales, sales support, and marketing. Linking RE to a company's business processes can increase

the usefulness of the RE process and support its organization-wide implementation as well.

4.3.5. Implementation of a RE tool

All the case organizations were interested in acquiring a RE tool. One case organization defined the RE process first, and subsequently acquired a RE tool. The use of the tool made a set of RE practices systematic and supported the organization-wide implementation of the RE process. Some practitioners were very satisfied with the tool, while others would have improved its implementation. The practitioners emphasized that their own company had to invest in tailoring the RE tool to the needs of product development projects. They wanted to have, for example, company-specific document templates and reports ready for product development projects.

One of the case organizations bought a RE tool to support the handling of the so-called raw requirements received from different sources. This organization defined its RE process after they had bought the tool. Some practitioners were satisfied with the tool. Some practitioners, however, said that it supported only partly the RE process of the organization, and that it was difficult get an overview of the requirements stored in the tool.

One case organization piloted a RE tool. People that participated in the piloting had different views on how useful the tool was. Some practitioners could not see real benefits to be received from the use of the RE tool. Some of them found it fundamental for managing a large amount of requirements. The piloting results were so promising that the manager of the RE process improvement project recommended that top management acquire the RE tool. However, top management decided not to buy the tool because they could not free any resources for the tool support.

The risk related to the implementation of a RE tool is that practitioners expect the tool to solve, for example, traceability and requirements management problems automatically. Another risk is that organizations underestimate resources needed for tool implementation and support.

The lesson learned is that a RE tool can support the organization-wide adoption of RE practices if it is well integrated with the RE process and implemented thoroughly.

4.3.6. Measurement

None of the case organizations was able to set measurable goals for RE process improvement, neither were they able to link process improvement goals with business objectives. The main reason for the difficulties in setting measurable goals was that the organizations did not have quantitative data from their existing RE practices. On the other hand, it is unrealistic to expect organizations that are just starting to improve their RE process to have measured their RE practices.

Managers were interested in evaluating the benefits and costs of the new RE process. One of the case organizations started to measure the number of requirements changes and to give people incentives based on the measurement data. Some of the practitioners found the measuring requirements changes troublesome, because people spent a lot of time on arguing about which of the changes were real and which were merely updates. These practitioners commented that the effort spent on arguing was a waste of time.

The risk related to measurement is that people might fear that the purpose of measurement is to evaluate their performance instead of evaluating the quality and the benefits of the RE process. Personal incentives that are given based on the measurement data can increase this fear. Another risk related to measurement is that organizations collect data without improving the RE process based on this data.

The lesson learned is that measuring the benefits and costs of the RE process could support the organization-wide implementation of the process. However, it is a difficult task to perform in practice.

4.4. Discussion

The key lesson of the study is that such human factors as motivation, commitment and enthusiasm are fundamental for the success of RE process implementation because the change of behavior starts from individuals. Our findings support those of Basili et al. [4], O'Hara [31], and Hutchings et al. [18]. For example, Basili et al. report that software process change is bottom–up and direct input from developers is a key factor in change [4]. According to O'Hara, winning the hearts and minds of people is crucial to a successful software process improvement [31]. Furthermore, Hutchings et al. point out that process improvement changes the way people work, and is fundamentally as much a human concern as it is a technical one [18].

We identified two characteristics of the RE process that are vital for successful implementation. First, the process must be useful for its users. If it offers concrete benefits, people can become motivated and committed to applying it in practice. In addition, Zahran emphasizes that any change to the current processes must carry with it benefits for project managers and software engineers [48]. Furthermore, Sakamoto et al. report that a most effective way to convince stakeholders, including software developers and top management, is evidence of problems in the current development and evidence of improvement [35].

Another important characteristic of the RE process is practicality. Practicality means that a process must be both simple and flexible. A simple RE process facilitates an understanding of the basics of RE by personnel and gives them an overview of RE. According to Armour, projects that are lacking awareness cannot use a detailed process because they do not know what process might work [1]. Furthermore, Ward et al. point out that processes must be simple because complex processes are difficult to follow and update, and quickly become unsuitable for the operations for which they were originally specified [43].

Successful implementation of RE processes requires training. 'Just-in-Time' training combined with learning-by-doing is an effective way to help people applying the RE practices in real product development projects. Hutchings et al. report that teams will invest themselves in the sometimes painful change of adopting new processes or techniques when (1) the teaching occurs when they are ready, (2) the teaching material is focused on their actual problem or situation, and (3) the teaching is accompanied by expert facilitation and consulting [18]. The experiences in our case organizations support this finding.

Our findings indicate that an RE tool can support the organization-wide adoption of RE practices if it is well integrated into the RE process and implemented thoroughly. According to Weber and Weisbrod, requirements management tools are the number one instrument for leveraging RE practices [44]. On the other hand, Hofmann and Lehner report that commercially available RE tools interfered with rather than supported RE activities [15]. They believe that either a lack of well defined RE processes or the RE team members' lack of training in using the selected tools caused this undesired effect. Our findings support the experience of Weber and Weisbrod. According to them, tool support represents both an opportunity and a risk in RE process improvement [44].

One of the main challenges related to RE process improvement is the duration of the change. In particular, the organization-wide implementation of RE practices requires patience, long-term commitment and investment. Similarly, Sommerville and Sawyer point out that organizations must budget for several years of improvement effort in order to gain the benefits after new RE processes have come into general use [37].

We recommend an incremental and people-oriented strategy for RE process implementation. By focusing on a small set of RE practices and by supporting their systematic usage, organizations can both shorten the duration of RE process improvement and gain lasting benefits from the improvement efforts. The main idea of the people-oriented implementation strategy is to emphasize that the purpose of the RE process is to help people do their jobs and to support learning by disseminating good RE practices across the entire organization. Our findings support the experience of Sommerville and Sawyer. According to them, it is important to respect professional skills and to emphasize that the point of changes is to help people improve the quality of their work [37]. They also point out that effective process improvement cannot be achieved by management instruction.

As a summary, the results of this study show that most of the factors critical to software process improvement are vital to the success of the organization-wide implementation of RE processes. The results also suggest that there are two factors that are specific for RE process improvement. First, introducing RE appears to involve a cultural change. Such a cultural change means that engineers have to change their perspective from a technology-centric view of product development to a customer-centric view of product development. Instead of describing requirements from a technical point of view, it is beneficial to define requirements systematically from the viewpoint of customers and users. According to our study, this kind of cultural change takes time and is demanding. Similarly, two other case studies [19,21] show that the cultural change towards systematic customer requirements management is both beneficial and challenging.

Another factor specific to RE process improvement is a close link between RE and business processes. This means that RE processes can concern not only product development but also such organizational units as a company's sales, sales support, and marketing. If marketing and sales personnel are assumed to participate in requirements definition, their perspective and needs should be taken into account and their representatives should be involved in RE process improvement work. One step further is to integrate RE processes with business processes more closely by specifying explicitly, for example, what kind of input information strategic and business planning provides for requirements definition, and what kind of outputs RE processes supply to marketing and sales departments.

Our findings also indicate that management commitment and support is particularly important if RE process improvement concerns other organizational units in addition to product development organization. In the RE literature, management commitment and support has not been emphasized. However, it is one of the key success factors for software process improvement (e.g. [5,12,14,24,28,30,31,33,46,48]).

In this study, the internal validity of the results was addressed by the triangulation of data sources and data collection techniques. Furthermore, the sample size can be considered to be rather large for qualitative research. The total number of different informants that were either interviewed or observed varied from 20 to 28. The sample size was approximately 10% out of product development and product management personnel in each case organization. Most of the informants represented the users of the RE process, i.e. persons who are responsible for defining requirements. In addition, the study covered lightly the perspective of other stakeholders such as product development managers, marketing and sales personnel. However in this study, the success of RE process implementation was investigated from the perspective of primary users of RE processes.

The presence of the researchers may have affected the internal and external validity of the results. The researchers acted as facilitators and participant-observers in the case organizations. From the perspective of the case organizations, their role was to support improvement activities and provide knowledge about RE. From the perspective of research, the researchers were observers that adopted a stance of neutrality with regard to factors affecting the organization-wide implementation of RE processes.

In addition, the research periods varied from 2 to 3.5 years, which allowed us to gain deeper knowledge about RE process implementation and validate the findings made at the beginning of the study. Therefore, we state that the success factors and challenges presented in this paper describe critical issues related to RE process adoption in the case organizations.

The external validity of the results is difficult to determine. One cannot generalize from the three cases, especially in the quantitative sense of word. On the other hand, one can learn from the study of three cases. According to Strauss and Corbin [39], if concepts (the categories, success factors and challenges in this study) are abstract enough, then they are likely to occur in similar or variant forms in other organizations. Moreover, it should be noted that most of the success factors identified in this study were in accordance with the literature. This indicates that the results may be applicable beyond the case organizations studied.

5. Conclusions

This study shows that the implementation of the RE process throughout an organization is a challenging undertaking and a complex phenomenon. The success of the organization-wide adoption of RE practices depends on human, organizational, technological, and economic factors. However, organizations can gain benefits from RE by defining a simple RE process, by focusing on a small set of useful RE practices, and by supporting the systematic usage of these practices.

From the research perspective, this study makes four contributions. First, it provides evidence that most of the success factors of software process improvement are similarly essential and applicable to RE process improvement. Furthermore, the results indicate that the close link between RE and business processes creates an additional dimension for RE process improvement. As far as we know, little research has addressed this topic and therefore, it is one of the future challenges facing the RE research community.

The third contribution of the paper from the research perspective is that it proposes a model of the factors affecting organization-wide implementation of RE processes. The model classifies the critical factors into categories and thus provides a structured view of them. In addition, it shows a set of relationships between the categories, which helps shed light on the complex phenomenon of the organization-wide implementation of RE practices. And, finally, the model highlights the significance of human factors, and provides some preliminary explanations why people may resist a process change.

From the practice perspective, the study offers a set of practical guidelines for RE process improvement and implementation. These guidelines and the list of the challenges can serve as a checklist when planning to introduce RE into product development. We do not suggest that these guidelines are complete, or that they will solve all the problems associated with the organization-wide adoption of RE practices. Careful consideration of them can, however, enhance the chances of success in implementing a new RE process throughout an organization.

The action research method, the multiple cases, and the long-term view of this study allowed us to examine organization-wide implementation of RE practices in depth and from the perspective of practice. This research approach also provides a broad insight into RE process implementation. We described seven success factors and six challenges in detail. However, there may be other important issues related to the organization-wide adoption of RE practices, not yet discovered.

The lessons described in this study were gained from Finnish organizations, and therefore there might be issues that may not be appropriate to other cultures. Even though the results are based on a longitudinal study, we were able to investigate the success of the RE process implementation in the case organizations for less than 3.5 years. A longer research period would probably provide more knowledge about process improvement aimed at organizational change, in other words, a change that would affect the entire organization permanently.

The results of the study point to several challenges for future research. First, one future research challenge is to obtain further confidence in our results by validating the success factors with new case organizations. Another research challenge is to extend the model of the factors affecting organization-wide implementation of RE processes by gaining deeper understanding of the interrelationships of the factors involved. Furthermore, it would be interesting to investigate, especially from the practice perspective, what can be done if a success factor is difficult to achieve in a case organization.

An important direction for future research is to gain further insights into human factors. Social scientists have studied changes in organizations from a people perspective, and therefore, valuable lessons can be learnt from other disciplines such as social psychology. Widening the scope of the RE process improvement research towards organizational change would also be significant. Management science has a long tradition of investigating issues related to organizational development and business process development. We believe that the research results from that discipline offer valuable knowledge for software process and RE process improvement.

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Appendix A. Summary of guidelines for RE process improvement and implementation (QURE: this study)

Success factor	Guideline	Source of the guideline		
		SE	RE	QURE
Human factors	Make all process users and managers aware of the RE process			x
	Ensure management commitment	x		x
	Cope with people's resistance against change	x		
	Support motivation, pride and enthusiasm of personnel	x		x
	Prepare to make a cultural change		x	x
	Support people in overcoming beliefs related to defining requirements from the customers' and users' points of view			x
	Respect skills of personnel involved in requirements engineering		x	x
Usefulness of the RE process	Provide benefits for all process users: • Provide concrete and short-term benefits for all process users [QURE]. • Provide managers with measurable data on the benefits of the RE process [QURE]		x	x
	Use the experience of the pilot projects to show the usefulness of the RE process			x
	Use the experience of the other companies to show the usefulness of the RE process			x
Practicality of the process	Define a simple RE process		x	x
	Define a flexible RE process			x
	Integrate the RE process with the product development process			x
Training	Train all process users: • Give managers, product development teams and other process users an overview of the RE process through training [QURE] • Use 'Just-in-Time' training to get product development teams to apply the RE process in practice [QURE]	x	x	x
Support	Ensure support from all management levels	x		x
	Offer simple templates and practical guidelines to process users			x
	Offer a RE expert to help product development projects			x
Implementation strategy	Use an evolutionary improvement strategy	x	x	x
	Improve the process continuously based on feedback	x	x	x
	Use a people-oriented strategy for RE process implementation			x
Improvement activities	Involve process users in improvement work	x	x	x
	Set goals for process improvement	x		
	Align process improvement goals with business objectives	x		
	Test the RE process in pilot projects		x	x
	Measure the impact of the improvement efforts	x		

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