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Methodology for Introducing Creativity in Requirements Engineering

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Abstract

The increase of global competitiveness, the ability of organizations to effectively use information technologies, and to focus on innovation and creativity are recognized as being important. In this context, the hypothesis of resorting to known creativity techniques or adaptations to help innovation in the field of Software Engineering appears to be challenging. This paper proposes a methodology for introducing creativity and innovation techniques in the Requirements Engineering process in order to build more agile and efficient Information Systems. The method uses a variety of creative techniques that are thought to be appropriate to the different stages of the process and is inspired by existing creative problem-solving methods and techniques, in particular in the Creative Problem-Solving Process, Productive Thinking Model and the Creative Potentiation Method. The study of the method allowed its application, through the use of various creativity techniques, in a real context in a social institution - the Social Center for Support to the Community of São Domingos. The application of the methodology allowed the identification of new opportunities that allowed the organization to devise service delivery strategies that were more suited to the needs of people.

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1. Introduction

Engineering is focused on fulfilling the needs of users or customers human beings or humanity [1]. From a pure engineering standpoint, the purpose of Requirements Engineering (RE) is to translate this (often poorly defined and vague) need into a formal and rigorous commitment so that engineers can build a solution. RE can be defined as the systematic process of requirements development through an iterative and cooperative process of problem analysis, documenting the resulting observations in various representation formats, as well as verifying the accuracy of the acquired understanding. This process requires creativity, interaction between people, knowledge, and experience. Based on this definition, RE is described as an application of engineering methods and techniques to analyze and solve requirements problems. Much of the research effort in RE has been focused on developing and evaluating different modeling methods and engineering techniques and defining project requirements most completely and accurately.

The ability of companies to effectively use information technologies and focus on innovation and creativity is now recognized as an important factor for a companies' competitiveness and agility. Organizations derive natural benefits from creativity and innovation by innovatively reorganizing their processes, projects, and products [2]. In this context, the possibility of using known creativity techniques or adapting them to mediate the generation of ideas, help produce new combinations, give unexpected, original, useful, and satisfactory answers in the area of Information Systems (IS), appears to be challenging. This paper, assuming a more limited scope, presents our research seeking to answer the following question: is it possible to propose a strategy for the introduction of creativity and innovation techniques in the RE process, with the objective of building more agile and efficient IS, which allow greater business competitiveness? Previous research work [3,4] reinforces the need to include creativity in the Requirements Engineering process.

The paper is organized into six sections. After the introduction, we present the methodology supporting this work. In section 3 we present a literature review with a state-of-the-art. In section 4 presents the strategy for introducing creative techniques in RE. At the section 5 we present our artifact, making an evaluation by applying it to a specific case and discussing it. We finish with the conclusion at section 6.

2. Methodology supporting the work

Design research is a paradigm widely used in IS that consists of the development of innovative artifacts to solve specific problems within a given domain and, thus, contribute to the production of new scientific knowledge [5]. Since we intend to design and implement an artifact, we consider this to be the most appropriate methodology for its elaboration, implementation, and critical analysis of the results. The artefact is the central element of the Design Science Research (DSR) and must be well tested, understood and documented to ensure its pragmatic validity. The evaluation is a central phase of the process, in which the usefulness, quality and effectiveness of the artefact are demonstrated, using well-executed evaluation methods [5]. The authors [6] present a mental model that synthesizes the main steps to carry out the investigation and respective evaluation through the DSR methodology (DSRM - Design Science Research Methodology), illustrated in Fig. 1.

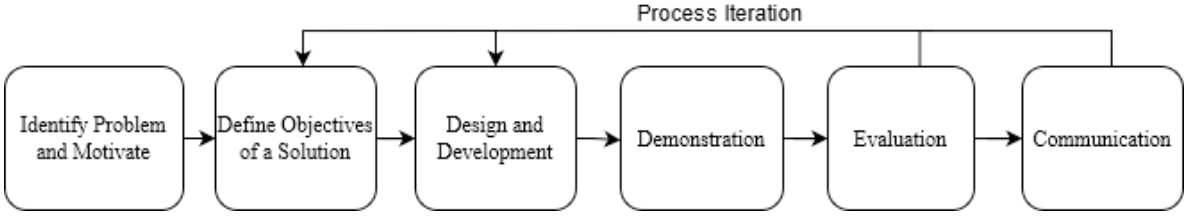

Fig. 1. DSR sequential activities [6].

This is a model of production and presentation of the results of design research commonly accepted in IS [7] and includes six sequential activities, as illustrated by Fig. 1. Given the specificity of the topic under investigation, it is

considered that the DSR methodology includes mechanisms that allow the conduct of the study from the identification of the problem and the objectives centered on the solution to the design and development of the artifact. The demonstration and evaluation of the solution will be carried out in a social organization.

3. Creativity in requirements engineering

The debate about the role of creativity in RE has received the attention of researchers and practitioners in the last years. Agreement exists about the value of creativity in RE and the urgent needs of more creativity-fostering techniques in support of RE activities. Many authors, and especially RE professionals, recognize and agree on the importance of the role of creative and heuristic techniques in the solution of engineering problems [8, 9, 10]. It is assumed that the essence of a problem is innovation, creativity, intuitive design, correct analysis, and effective project management. Also, prior knowledge provides useful information on previous projects and helps practitioners in the early stages of idea generation [11]. Research on how creativity is applied in this engineering activity has been neglected [12]. Creativity allows requirements engineers to deal with new problems and domains, unique contexts, new applications, and combinations of existing methods and techniques.

The issue of Creativity in RE has received increasing attention from the community. Creativity workshops and tutorials have been held continuously at major requirements engineering conferences, such as the RE (IEEE International Requirements Engineering Conference) and AWRE (Australian Workshop on Requirements Engineering). The latest creativity research efforts in RE can be classified into the following main areas: understanding and facilitating the creative problem-solving process [13], development of brainstorming techniques to perform requirements gathering [8], incorporation of creativity in RE teaching [14,15] and investigation of social factors and contexts, where creativity is exerted in RE [16].

Maiden and his colleagues [17] used creative workshops to simulate and structure the creative process of RE. Nguyen and Swatman [13] associate the preparation and incubation phases with the creative and reflective structuring of the requirements model. They suggest that various creativity techniques, such as brainstorming, scenario and simulation generation, and ad hoc design, could be used to support and promote creativity during these phases. The authors [18] such a transformation constitutes a major endeavour for requirements engineers who need to identify, specify, and analyse the effects that a multitude of assets need to be transformed towards a network of collaborating devices, information sources, and human actors.

4. Requirements Engineering Creativity Strategy

This section presents the strategy for introducing creative techniques in RE and a generic method that operationalizes it. In IS, particularly in the context of creativity, the importance of RE activity in the definition of the systems to be developed at the IS architecture level is highlighted. On the one hand, to ensure they are aligned with the strategy of the companies, on the other, the need for this activity to be creative and innovative, enabling the development of more competitive and adaptable solutions to environmental changes. Despite the evidence given and the quality and interest that each of the structured methods of supporting the existing creative problem-solving process reveals, none is completely adequate to support the introduction of creative processes in RE.

However, although existing methods and techniques are not sufficiently complete and adequate for our purpose, there are some methods and principles in these methods and techniques that may meet some of the requirements. For example, the need advocated by Osborn and Parnes in the Creative Problem-Solving Process (CPS) [19], and reaffirmed by Hurson in the Productive Thinking Model [20], to clearly define and understand the objectives and purposes of the problems, before moving on to the idea generation phase. Additionally, the assumption of Root Cause Analysis (RCA) is that the focus should be on the source of the problem rather than the symptoms - determining solutions that solve root causes is one of the keys to the success of complex systems, and the general understanding that a good idea does not necessarily mean a good solution, so it is mandatory to consider a phase of converting ideas into solutions that can be implemented.

Some authors classify the more than two hundred existing techniques in schemas for exploring attributes of a problem, namely generating alternatives, visually exploring metaphors and analogies, and evaluating and

implementing ideas. This great diversity of creativity techniques is promising for our goal since the activity of RE has a wide context - it covers the whole organization and its surroundings and the most varied branches of activity and technologies - this means, in practice, to have multiple tools available and to choose the most suitable one for each specific situation. On the other hand, we assume that most of the time, any creative process that may have real utility for RE is complex, so it will be advantageous for it to be governed by a structured method that is powerful enough to yield relevant results, but also, flexible enough to be usable and fit for any organizational context and any RE approach. All these factors justified the creation of a specific structured strategy for the introduction of creative processes in RE.

This strategy, presented in Fig. 2, supports itself in a variety of creative techniques that are thought to be appropriate to the different stages of the process, due to their characteristics, and is inspired by existing creative problem-solving methods and techniques, in the Creative Problem-Solving Process, Productive Thinking Model and the Creative Potentiation method.

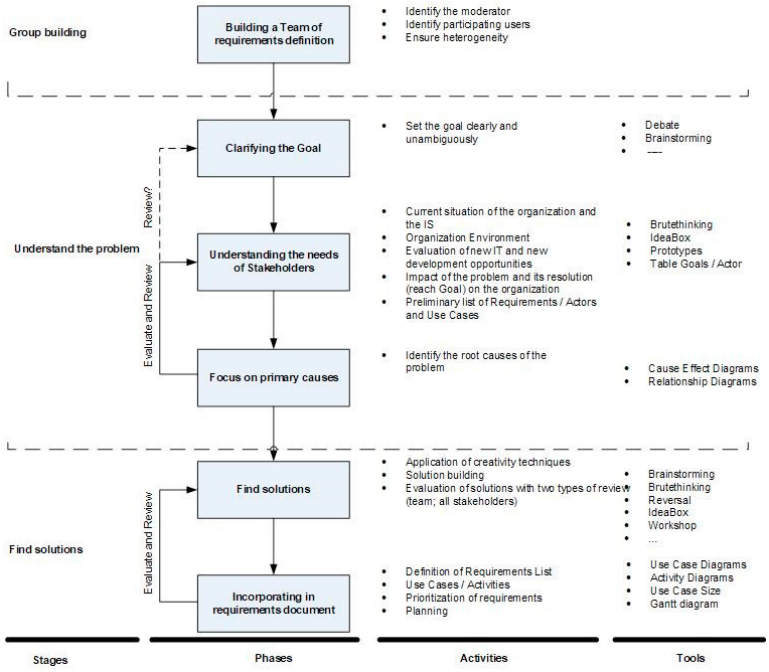

Fig. 2. Process for introducing Creativity into RE.

As shown in Fig. 2, the process begins with the working group formation phase, called “Building a Team of Requirements Definition,” aiming to establish the team that will apply the method. In phase 2, “Clarifying the Goal,” we seek to formulate a concrete objective. That is, to provide a framework to help understand issues that can contribute to an effective and clear definition of an objective that serves to solve the problem confronting the organic entity. Problem framing helps to move from a generic problem to a specific problem. We suggest the application of the Brainstorming technique, that is, a meeting to encourage the complete liberation of mental activity, without restrictions [21].

Phase 3, “Understanding the needs of stakeholders,” aims to identify user requirements in the process of finding a creative solution, interaction with stakeholders to identify their needs and find out what needs to be built, direct observation which is then used to understand the social and organizational requirements better and to help discover implicit requirements that better reflect real processes than formal processes, identify and consult all sources of requirements, and ensure the intervention of project managers and other elements. Existing applications and prototype building are used as a source for gathering and validating requirements. The preliminary list of requirements, with

actors and their objectives (Use Cases), is elaborated. Activities in this step include prototype analysis using the IdeaBox creativity technique.

In phase 4, "Focus on primary causes," we identify the primary (root) causes that are at the source of the problem. After understanding the application domain requirements, the problem to be solved is identified in the business context of the organization. This analysis is done according to the needs and constraints of the stakeholders. For this purpose, the elaboration of the Relationship Diagram is proposed.

Phase 5, "Find Solutions," aims to build and evaluate solutions considering the Organization's objectives and needs. Different creativity techniques are applied to come up with innovative solutions that address the underlying causes already identified. Thus, the creativity techniques proposed for this step are Brutethinking, Reversal, and IdeaBox. The Brutethinking technique is characterized by being a simple process, developed in four steps as follows, first choosing a random word, then choosing things/elements associated with the randomly chosen word, next forcing a link between the word and the problem and between the associations and the problem, and finally listing the ideas obtained and analyzing them [21]. The Reversal technique has its origins in the transformations that generate ideas. In some cases, it is better to think first of the negative and then reverse the negative, indicate "the worst," and then revert to "the best". IdeaBox is a tool that allows one to combine the parameters (characteristics, factors, variables, or aspects) of a challenge into new ideas [21].

The iterative process ends with phase 6, "Incorporating in requirements document," which aims to incorporate the outputs of the requirements engineering process, namely, the documentation that results from application domain information, the list of requirements and support diagrams, specific information with requirements priorities (including interaction with stakeholders to find out the most important requirements), any prototypes of the system, risk assessment, and project management planning. The methodology uses the Reversal Creativity technique to assign or reassign the size classification to Use Case, allowing for better prioritization during the RE process.

For the purposes of analysis, validation, and quality assurance of requirements, we propose to carry out requirement reviews at two levels, first internally and then in extended meetings involving the various stakeholders. The study of the method allowed its application, using various creativity techniques, in a real context in a social institution - the Social Center for Support to the Community of São Domingos.

5. Applying the Creative Methodology in Requirements Identification

The Community of São Domingos (CSD), in Setúbal, is part of a Social Center. In the context of the optimization of the IS and the Information and Communication Technologies (ICT) of CSD, and after several working sessions and within the scope of Identification of Innovation Opportunities, the objective is to optimize the IS and ICT that support the organization's activity. The application of the methodology was focused on the creative component of requirements gathering, in order to understand the current situation of the organization. A heterogeneous group constituted the team with elements from various areas, namely, the Project Manager, with experience in IS optimization, the team member with experience in the RE process, the Software Architect with experience in development, and the CSD Manager (end-user). The first session aimed to identify Information Systems Opportunities and characterize the population of the CSD in various aspects. The session was assisted by the CSD Officer to analyze the gaps in the current IS. The Project also included an Engineer skilled in the application of creativity techniques to validate the methodology.

The organization's status quo was surveyed based on meetings between the Project Manager and the CSD Manager, together with the participation of the Software Architect. The project development also counted on the online collaboration of the Requirements Engineer. Following the characterization of the CSD, the team followed the steps that underpinned the project, namely, objectives clarification, understanding the needs of the organization, focusing on primary causes, requirements gathering, solutions finding, and integration in the requirements document. The main problem was analyzed, and the eventual solution was discussed (goal), verifying the need to "improve the current IS in order to provide better services to the community," in an integrative approach to the CSD citizen.

With the characterization of the CSD, namely the entities involved and the role they play, we moved to the phase "Understanding the needs of stakeholders," in which the CSD actors and their objectives were identified, allowing the creation of the preliminary list of requirements and subsequently of the Use Case Diagram. After ponderation (based

on the brainstorming technique), the primary causes were pinpointed, and a Relationship Diagram (Fig. 3) was elaborated to identify and list the primary sources of the problem.

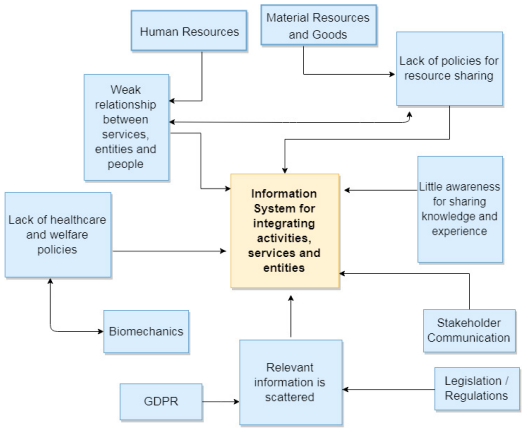

Fig. 3. Relationship Diagram - Primary Causes of the Problem.

An evaluation meeting was held to identify the root causes of the problem, as summarized in the following table (Table 1).

Table 1. Primary Causes.

Most likely primary causes	Processes Used to List Primary Causes
Lack of an IS that integrates the activities, services, and official entities.	Attempt to use aggregated information on a spreadsheet
Dispersion of relevant knowledge and information	Attempt to share information and knowledge
Lack of healthcare and welfare policy; resource sharing	Do not exist

In order to "Find Solutions," considering the needs of the Organization and the primary causes, different creativity techniques were applied in an attempt to find innovative solutions that address these causes. At this point, we proceeded to the selection of the most appropriate creative techniques apropos the specificity of the organization under study. In this sense, we selected Brutethinking and Reversal techniques.

During the application of the methodology, namely the Brutethinking creativity technique, the word sustainability associated with the problem emerged. On analysis of the ideas obtained, the use of the creative requirement for the inclusion of sustainability in the human, economic, environmental, technical, and social dimensions was proposed. These dimensions of sustainability are embodied in the Karlskrona Manifesto [22], where requirements engineering is the key point through which sustainability can be promoted. In this regard, we repeated the creative process from the dimensions of sustainability to collect the associations between them. Thus, Fig. 4 presents the result of this reflection with the solutions found. The application of the creative process to the various dimensions of sustainability resulted in the identification of sustainability keywords in CSD (Fig. 4). This step allowed the listing of new requirements, notably in the design of the application for the creation of volunteering programs (for example: within the community for minor repairs to housing, or outside the community for protection of the sea environment); consumer goods sharing (e.g., food too good to be discarded) and car sharing (application with the schedules of people with a car to share).

Fig. 4. CSD Sustainability Keyword Diagram.

In the "Incorporating in requirements document" phase, after validation, the list of CSD actors and their objectives and, later, the Use Case Diagram were incorporated. The activities of this step included the analysis of prototypes (purpose-built) using the IdeaBox creativity technique. The Reversal Creativity technique was used to assign the size classification to the Use Cases, allowing for better prioritization of requirements. The Activity Diagram for CSD Volunteering has been prepared as an example to clarify the responsibilities of each actor.

The team used the Brutethinking technique in three iterations to identify the problem, the main objective, the root causes, the system actors and their objectives, the functional and non-functional requirements, and the creative and non-creative requirements. It also used the techniques of debate and Brainstorming, to evaluate and review artifacts and solutions found. In the scope of the study case the definition of Non-Creative Requirements and Creative Requirements, was also possible, and an added value, to enhance the valences of the organization.

Non-Creative Requirements: Coverage - in the sense that one specifies component(s) that the current SI does not address. In this specific case, sharing of resources and assets (donated or not); volunteering platform; Improvement - allows one to specify the improvements that the IS will be able to include. In the case under study, we consider improvements to create a community based on a computerized IS, and then the digital transformation took place on paper; Integration - opportunity to analyze the relevance of integrating services/valence in the IS. In the case of CSD, services, activities, and entities will be integrated into an IS.

Regarding Creative requirements: A new feature has been included - Sustainability in the human, economic, environmental, technical, and social dimensions; New Services: car sharing; resource sharing; taking medication; prototype integration of various valences and entities; Disruptive methods: offering services performed by direct exchange or at a much lower value; creation of the volunteering platform with internal or external community tasks; establishing partnerships. CSD experts who participated in the Information Systems Opportunities process considered the added value of the proposals and creative techniques, concluding that these techniques were enriching in the specific context of the organization.

6. Conclusion

The creative method was applied to a real case by experiencing difficulties and drawing lessons. In the application, it was observed that the use of the method for the introduction of creativity in RE had created added value to identify opportunities that will allow the organization to provide well-integrated services that are better suited to people's

needs. On the other hand, the difficulties were concentrated on the introduction of creativity techniques, caused due to the lack of skills in the IS and ICT fields of the institution's employees. After evaluating the innovative requirements, the decision was to implement the modules in stages in the medium term - an appropriate option owing to the size and complexity involved. The iterative process of the DSR methodology allowed the characterization of the organization as well as the development and validation of the artifact. Overall, it was concluded that creativity techniques were applied at the appropriate level, having achieved the goal of developing innovations in the organization. Innovation and creativity, at the technical and/or functional level, are also considered to be important factors for product success. Thus, the participation of elements with capabilities in these areas has also proved to be very important. It is considered that the method used proved to be different from the existing ones as it supports a variety of creative techniques that were suited to the different stages of the process, inspired by creative methods of problem solving.

As future work, we intend to include sustainability factors in the creative method associating the Sustainable Development Goals. Another strand of work that can be an added value will be to analyze the organization's representation by its DNA and use the corporate architecture framework for this purpose [23]. The methodology will be applied in the academic context and later in industry.

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