A Goal-oriented Method for Requirements Prioritization

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***Abstract*—In today's global economy where organizations must constantly transform themselves, prioritization of information systems (IS) requirements is crucial. Different techniques have been proposed to automate the IS requirements prioritization process. Still, existing techniques suffer from a number of limitations and their implementation are mostly informal. This work aims to design a novel method for IS requirements prioritization. Our method is based on the Goal-oriented Requirement Language (GRL), which links requirements to the business objectives/goals of the organizations. Our method allows stakeholders, such as business analysts to model requirements and objectives using GRL and then evaluate the impact of requirements choices on organizations' objectives. In this paper, we present the principles underlying our method for automating the prioritization of IS requirements and discuss issues for future research.**

Keywords*—*Requirements Prioritization; Requirements Engineering; Goal-oriented Requirement Language.

I. Introduction

The success of transformation projects is conditional to the proper management of the requirements of Information Systems (IS) [1]. Indeed, with organizations often facing time, resource and budget constraints, IS projects are more often than not delivered late and over budget since they have to implement a large number of requirements [1]. Furthermore, since enterprise resources are limited, it is becoming increasingly difficult to implement all the elicited requirements [2] [3]. Thus, to help stakeholders improve IS projects performance, organizations must select the most critical requirements to implement [1]. Requirements prioritization helps to overcome this challenge by classifying requirements according to their relative importance [1][3][4]. According to Mulla and Girase [1], requirements prioritization optimizes Information Technology (IT) investments by targeting the most important functionalities. In addition, conflict situations are often raised during the elicitation process because of stakeholders diverse interests, needs and priorities. Stakeholders go through negotiations in order to select the most important business needs to be addressed, which implies that requirements need to be prioritized [5]. According to [4], requirements prioritization gives the right tools to decision makers to solve conflicts, take strategic decisions in order to control IT project costs, deliver value and optimize the return on invested resources.

The importance of requirements prioritization has motivated research initiatives and many approaches were proposed including [3][4][6][7]. This research main objective is to propose a unified IS requirements prioritization method. A prioritization approach is unified when it meets quality attributes, such as usability, transparency, efficiency, adaptability, flexibility and genericity. Our approach is based on a goal-oriented method that allows to model and evaluate the impact of requirements choices on the organization objectives. The proposed method is generic since it can be used by organizations regardless of their activity sector, their specific structure or the nature of their IS projects.

A. The Methodological Approach

We used the Design Science Approach (DSA) to conduct our research project. Hevner and Chatterjee [8] presented design science as a research approach that aims to answer questions related to relevant issues through the creation of innovative artifacts. The design science methodology is articulated around five main activities, namely: Problem identification and motivation, Definition of the artifact objectives, Design and development of the artifact, Demonstration, and Evaluation of the artifact [9].

B. Theoretical and Practical Contributions

This research aims to provide both a theoretical and a practical contribution. From a theoretical perspective, the research will proposes a unified method for prioritizing requirements based on the use of the Goal-oriented Requirement Language (GRL), which is part of the URN (User Requirements Notation) standard [10]. GRL enables the explicit modeling of objectives, requirements, alternatives and their relationships. This is why we chose to use GRL to design and develop a unified method for requirements prioritization. We mean by unified method that it can be applied in different types of IS projects and by different types of organizations, regardless of their size, activity sector, or the technical skill level of the project stakeholders. Hence, the unified method we propose can be adapted to the particular context of any organization without any dependency on situational elements.

The unified method addresses the limits of previously proposed approaches. In [4], Wohlin compared five prioritization techniques on the basis of their measurement scales, the granularity of the analysis they provide, and their level of sophistication. The granularity of the analysis represents the level of accuracy of the prioritization results that are presented in the measurement scale. The level of sophistication represents the level of complexity of the assessment on priority of components. The results of this comparison are shown in Table I. According to the author, a value scale is strong when it allows the results to be measured and presented with high accuracy. In other words, the higher the value scale, the more refined is the granularity of the analysis and therefore the more sophisticated the technique (see Table I). As a result, the unified method tends to find a balance between granularity and sophistication.

TABLE I: SUMMARY OF THE PRIORITIZATION TECHNIQUES [4].

Technique	Scale	Granularity	Sophistication
AHP	Ratio	Fine	Very Complex
Hundred-dollar test	Ratio	Fine	Complex
Ranking	Ordinal	Medium	Easy
Numerical Assignment	Ordinal	Coarse	Very Easy
Top-ten	-	Extremely Coarse	Extremely Easy

From a practical perspective, the proposed method helps IS practitioners to improve the quality of their requirements prioritization activity. Today, practitioners use different approaches to prioritize requirements that produce inconsistent results. They cannot simply choose the most sophisticated prioritization techniques since, according to Wohlin [4], the more sophisticated the technique, the more difficult and time consuming is its usage. For Wohlin [4], the solution is to make a compromise between the level of precision in the analysis of the prioritization and the time needed to perform the prioritization. The proposed method offers a good compromise between accuracy and ease of use. Therefore, we believe that by addressing the limits of other methods, we will increase the adoption of the proposed method by IT practitioners.

II. Literature Review

Several scientific papers have proposed approaches to help prioritize IS requirements. The Must, Should, Could and Would (MoSCoW) prioritization technique classifies requirements into four broad categories that designate the overall level of priority of requirements [6]. Some researchers, such as Achimugu *et al.* [2] and Hatton [11] have criticized the MoSCoW technique for its inability to identify the relative importance of one requirement over another. This is an important limit, since the identification of the relative importance provides access to a more detailed level of information on the requirements, which will make it possible to better prioritize and consequently deliver the best system value to the customer [11]. As a result, MoSCoW does not effectively prioritize requirements.

The prioritization process proposed by Kaymaz [7] prioritizes business and IT change requests based on three types of priorities: general, business and IT priorities. In order to establish the business priority, Kaymaz's [7] process uses the FMEA (Failure Mode and Effect Analysis) quantitative tool of the Six Sigma methodology. According to Ashley and Armitage [12], Franklin *et al.* [13], and Shebl *et al.* [14], the results originating from the FMEA tool show a large variance, indicating a lack of reliability and efficiency.

Rahmouni *et al.* [3] proposed a method that prioritizes IS requirements by grouping them according to their similarities, commonalities, synergies, and their technical dependency relationships. According to these authors, their method has limitations because it does not take into account the business objectives.

Despite the number of works proposed to prioritize IS requirements, existing approaches have several shortcomings e.g., the MoSCoW technique [6] is not effective, FMEA-based approaches [7], the method proposed by Rahmouni *et al.* [3], and those presented in Table I lack of usability, reliability and efficiency. In addition, to date and to the best of our knowledge, there is no unified method that prioritizes requirements based on their contribution on business objectives. The contribution of this work is twofold: 1) from a structural perspective, it proposes a novel method for IS requirements prioritization that takes into account business objectives as well as technical and business dependencies; 2) from a usability point of view, this research aims to address the limits of the approaches presented in Table I by proposing a method that is generic, adaptable and easy to use.

III. A Prioritization Approach by Modeling Objectives

To design our method, we had to look for an easy and practical tool, which enables us to both link requirements with business objectives and evaluate the impact of the choice of requirements on objectives. We found that GRL [10] would support the achievement of these research objectives. GRL is standard for goal-oriented modeling. It is part of the URN (User Requirements Notation) standard, a Recommendation of the International Telecommunications Union [15]. GRL makes it possible to model explicitly the objectives, the requirements, the alternatives and their relations. GRL can also model and evaluate the impact of requirements on objectives, allowing stakeholders to observe and understand why some requirements should be prioritized. The explicit modeling makes GRL a tool that supports the evaluation and the analysis of the best compromises between different objectives of stakeholders in a manner to avoid conflict situations. As a result, GRL can help IT managers' decision-making by empowering them to identify the best alternative.

The basic elements of the GRL language are shown in Figure 1. Section (a) of the figure presents the intentional elements of GRL, such as the goals, soft-goals, tasks, and resources. A goal is quantifiable while a soft goal refers to qualitative aspects that cannot be measured directly (e.g., customer satisfaction) [10]. Soft-goals are usually related to *Non-Functional Requirements* (NFR), while goals are related to *Functional Requirements* (FR). Tasks are solutions to goals or soft-goals [10]. The section (b) presents the GRL links, such as the decomposition, contribution, correlation or dependency links [10]. These links are used to connect elements (e.g., NFR, FR, Solutions, etc.,) in the requirement model. An intentional element can be decomposed into sub-elements

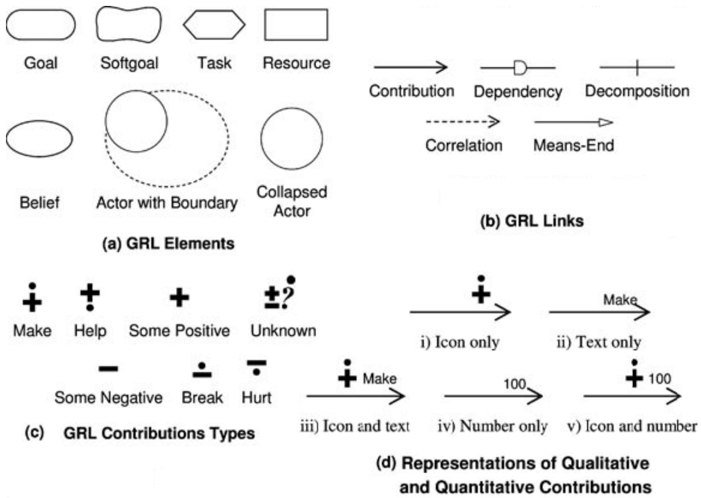

Figure 1: Basic GRL elements [10].

using decomposition links. The correlation links show side effects between the intentional elements. The relationships between the actors are illustrated using dependency links. The section (c) of the figure presents the contribution types used to model qualitative or quantitative impacts of an element on another. These impacts are propagated through the contribution links presented in section (d). In the next sections, we present our method as proposed by Peffers *et al.* [16] for design science works.

IV. The Problem

The starting point for initiating research activities in design science is a specific field problem that emerges from an external environment. In the context of our research, based on our literature review, we noted the importance of prioritizing requirements in organizations. However, despite the many advantages of prioritizing requirements, there are no unified methods for prioritizing requirements. Therefore, we formulated our research problem based on this finding. Although several requirements prioritization approaches exist, they have not been standardized in a manner that the IT community can use them (see Section II).

V. The Artifact: The Prioritization Method

The second step consists of defining the artifact whose purpose is to solve the problem. The artifact that was designed and evaluated in our research project is a method. In order to make our method unified, we made sure that it meets quality criteria, such as usability, transparency, efficiency, adaptability and genericity. By usability, we mean that the method is easy to use by a stakeholder who does not have the technical skills to design or develop IS solutions. The method is also transparent, so that all stakeholders can see and understand the selection of the requirements to be prioritized and implemented. In addition, the method is effective in a sense that it achieves its original purpose, which is the prioritization of the requirements in a simple and fast manner, while producing a result deemed acceptable for an experienced business analyst. The proposed method is also generic as it can be applied to prioritize IS solutions from different business domains. Finally, the method is adaptable, meaning that its use can be adapted to fit specific organizations needs.

VI. Design and Development of the Prioritization Method

The design of the method was based on the following four main functions: grouping, explicit modeling, evaluation and prioritization (see Figure 2). The grouping function is used to group requirements that share different categories of relationships. This function consists of identifying and grouping requirements that share relationships of similarity, commonality, synergy, technical and business dependency [3]. The grouping function is important since it optimizes the requirements prioritization process while facilitating and reducing inefficiencies [3].

The explicit modeling function allows a clear and accurate representation of the requirements, objectives and relationships that exist between them. In this fashion, all the stakeholders involved will be able to better see and understand, in a transparent way, the requirements to be prioritized. The modeling function allows reaching a common understanding. On the one hand, explicit modeling will be easy to use so that a stakeholder without technical skills can work with it, thus meeting the usability requirement. On the other hand, using explicit modeling enables the method to clearly evaluate the choice of requirements through their interrelationships and their impacts on the organizations objectives. This requirement evaluation function, combined with the modeling function, allows to assess the impact of the requirements choice on the objectives.

We have integrated and adapted the GRL language to build our method. GRL provides the means to perform all the functions and to achieve the quality attributes that make our artifact a *unified method* for requirements prioritization. By incorporating the GRL language into our method, it is possible to explicitly model requirements, business objectives and their interrelated links. By being able to show impacts of the requirements on the objectives through GRL, it is now possible for stakeholders to have both qualitative and quantitative evaluations of their requirements choice. The last function prioritizes the requirements. It is based on the results of the evaluation function. More precisely, this function consists of comparing the results of the GRL evaluation performed in the previous step in order to prioritize the requirements.

VII. Example : Library Loan Management Case

We applied our approach to prioritize the requirements of a library loan management IS. To illustrate our approach, we limit the prioritization to two groups of requirements: the automated invoice emailing and the automated invoice printing for postal mailing. The product owner wants to establish an order of priority to address these functional requirements. The process starts with the requirement grouping function to identify the GRL elements that share the relationships of

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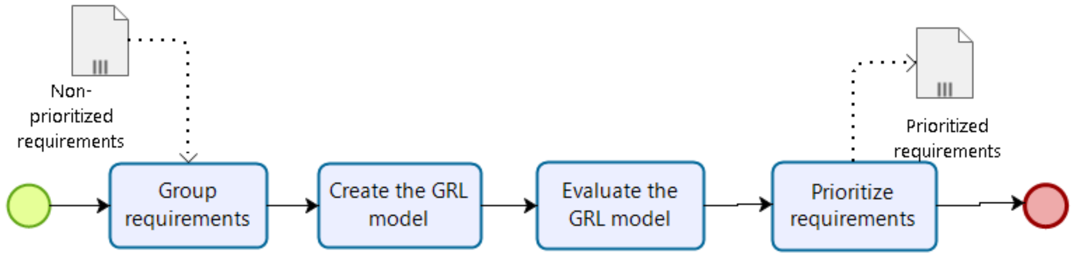

Figure 2: The functions of the proposed method.

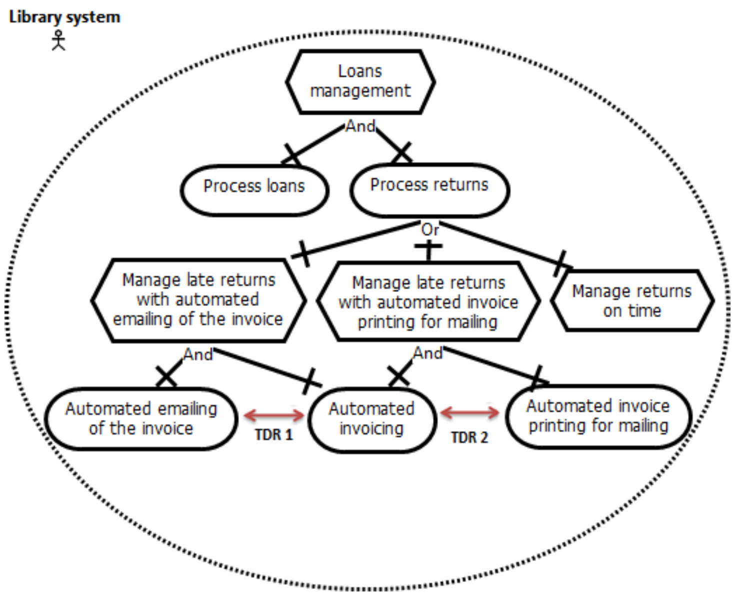

Figure 3: GRL model of the library loan management system.

similarities, commonalities, synergies, technical dependencies and business dependencies.

A first Technical Dependency Relationship (TDR 1) exists between the two functional requirements: the automated invoicing and the automated emailing of the invoice. Indeed, emailing the invoice requires that the invoice be generated. Similarly, a second Technical Dependency (TDR 2) exists between the automated invoicing and automated invoice printing for mailing requirements. In fact, printing and sending the invoice requires that the invoice be generated first.

Once we have identified the requirements and related elements, we must establish an order of priority of the requirements having technical dependency relationships. This is the second activity of the requirements grouping function. This order can be expressed as a Technical Dependency Sequence (TDS) between requirements.

Due to TDR 1, there is a first Technical Dependency Sequence (TDS 1) between the automated invoicing requirement and the automated emailing of the invoice requirement because emailing the invoice requires the invoice to be generated first. Due to TDR 2, there is a second dependency TDS 2 between the automated invoicing and the automated invoice printing for mailing requirements because printing and sending the invoice also require the invoice be generated.

Before starting the prioritization process, and to avoid inefficiency, we must consider all existing technical dependencies between requirements and establish the relations or sequences between them. The requirements that share these technical dependencies are interdependent. Inspired by the work of Rahmouni *et al.* [3], we grouped interdependent requirements both when they share technical dependencies, and when they share relationships of similarity, synergy, commonality, and business dependency. Using relationships that exist between requirements optimizes the prioritization and reduces inefficiencies [3]. In addition, a product owner (e.g., business analyst) can more easily prioritize inter-related and interdependent requirements per group than if he prioritizes each requirement individually.

There is no relationship between the automated invoice emailing and the automated printing for postal mailing functional requirements. Therefore, these two requirements are independent. Consequently, we can place them in two distinct groups.

After grouping the requirements, we need to create the GRL model that links the requirements, tasks/solutions and business objectives. The resulting GRL model is presented in Figure 3.

Once the GRL elements and links were represented, the evaluation criteria must be defined. In our case, the require-

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ments were evaluated on the basis of their contribution to the business objectives, such as reduction of costs and payment delays. Quantitative contributions of functional requirements to business objectives are values within the range of -100 to +100. The main business goal is cost reduction; we gave it a value of 100. As for the goal of reducing payment delays, we gave it a value of 75. Note that the GRL modeler (e.g., business analyst) can use other values that best reflect the practices or needs of their organizations.

We then assessed the impact of the requirements on business objectives by analyzing the requirements to determine their types of quantitative contribution on the objectives. Each type of qualitative contribution generally leads to a marginal quantitative value of 25 or –25, depending on the level of positive or negative impact of the functional requirement on the business objective (see Table II).

TABLE II: QUANTITATIVE CONTRIBUTION VALUES FOR QUALITATIVE CONTRIBUTIONS [10].

Qualitative contribution	Quantitative contribution
Make	100
Some Positive	75
Help	25
Unknown	0
Hurt	-25
Some Negative	-75
Break	-100

After analysis, it was established that the automated invoice emailing did not generate any costs. Therefore, this requirement makes a positive contribution to the cost reduction objective, which represents a quantitative value of 100 (see Table II). Also notice that sending and receiving the invoice by email is instantaneous, therefore it helps to reach the goal of reducing payment delays, which represents a value of 25 as the subscribers are more likely to pay invoices upon faster reception. We then modeled the first set of requirements with TDR 1, TDS 1 and their quantitative contributions to the objectives. The resulting model is shown in Figure 4.

In Figure 4, the TDR 1 relationship is represented by the *brown double arrow*, and the TDS 1 sequence is indicated by the *brown arrow* that starts from the automated invoicing and ends at the automated emailing of the invoice requirement. The idea that sending and receiving the invoice by email are done faster is shown by the belief link in Figure 4. Since the cost reduction objective has a value of 100, we multiplied the value of the contribution by the value of the business objective and divided the total by 100, because the contribution of the functional requirement is between -100 and 100. The calculation is as follows: (100 x 100) / 100 = 100.

Similarly, we multiplied the value of the second contribution by the value of the reduction of payment delays objective and we divided it by 100, that is: (25 x 75) / 100 = 18.75.

The functional requirement of automated printing for mailing brings recurrent costs since printing generates costs associated to paper and ink use. In addition, there are other recurring costs related to postal mailing, such as envelopes and stamps. As a result, this requirement is harmful (Hurts) to the cost reduction business objective, which represents a value

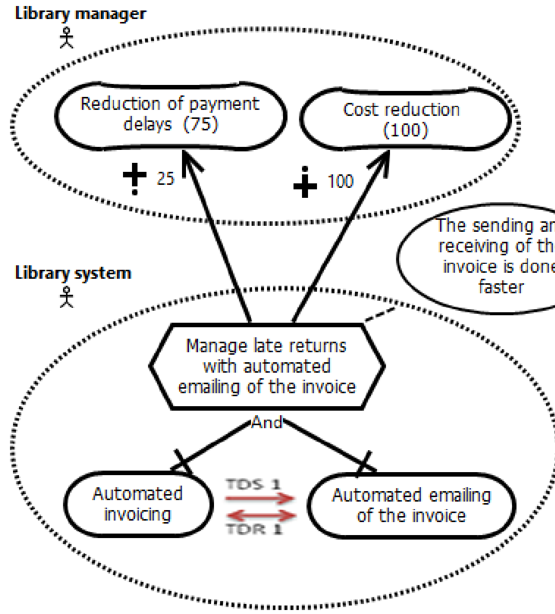

Figure 4: Group 1 of the library system requirements.

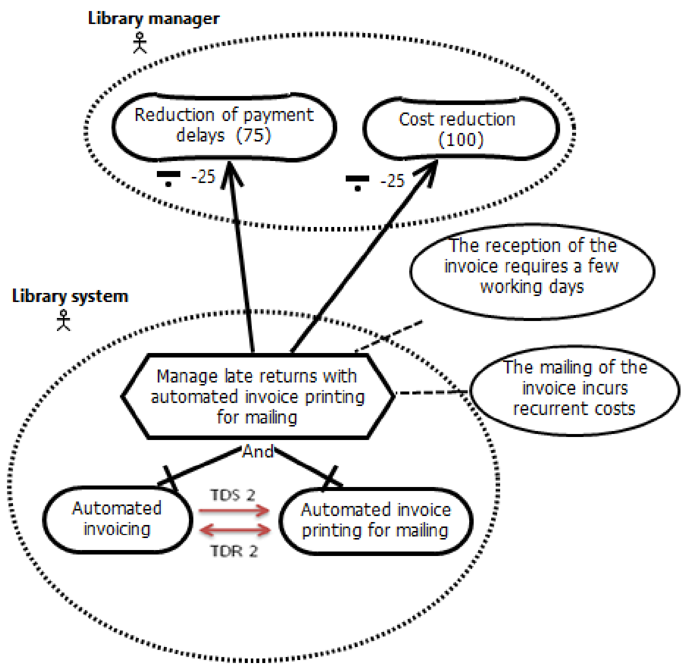

Figure 5: Group 2 of the library system requirements.

of -25. Furthermore, the invoice reception by mail requires a certain number of working days, which extends the payment period. As a result, this requirement is detrimental to the goal of reducing payment delays, which represents a value of -25. The modeling of this group of requirements is presented in Figure 5.

With respect to the evaluation score of this requirement on the cost reduction business objective, the calculation is as follows: (-25 x 100) / 100 = -25.

With regards to the evaluation score of the requirement on the payment delays reduction business objective, the calculation is as follows: (-25 x 75) / 100 = -18.75.

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After the requirements assessment, the prioritization function is performed. To do so, the method computes the total evaluation score of each requirement group of all business objectives. The higher the score of the evaluation, the higher the priority of the group. Table III shows that the total score of the evaluation for group 1 (118.75) is higher than the one for group 2 (-43.75). The implementation of Group 1 is therefore prioritized because its contributions to the business objectives are greater than those of Group 2.

TABLE III: PRIORITIZATION OF REQUIREMENT GROUPS.

Group	Business Objective		Total	Priority
	Cost reduction	Payment delays reduction		
Group 1	100	18.75	118.75	1
Group 2	-25	-18.75	-43.75	2

VIII. Preliminary Validation

We conducted a preliminary evaluation of the proposed prioritization method through the library loan management system presented in Section VII. We presented the results of our approach to a group of twelve graduate students from an internationally renowned management school known for its in-depth business analysis skills. All students had a good knowledge of the GRL language. We asked them to evaluate the approach through a questionnaire on the effectiveness and usability of the method. The other quality attributes of the method presented in Section V were not evaluated in this preliminary experiment.

As shown in Figure 6, 10 of the 12 students (83.33%) found that the method is effective and usable in the context of the library loan management system. Two students (16.67%) found that the GRL notation and the evaluation process are complex and made the method less useful for stakeholders such as business analysts.

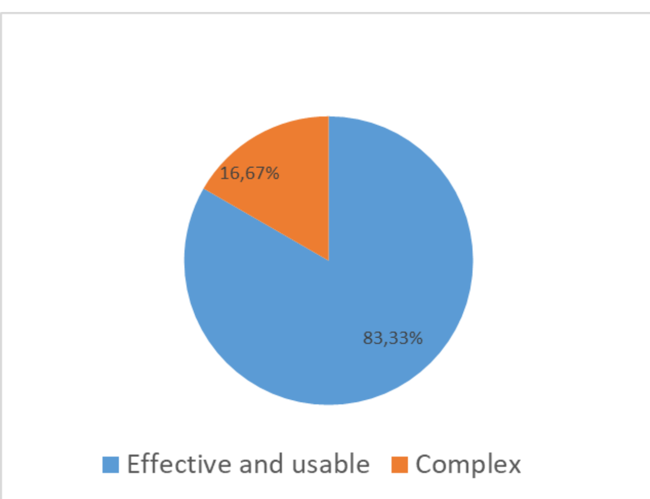

Figure 6: Evaluation of the effectiveness and usability of the method.

IX. Conclusion and Future Works

This research demonstrates that it is possible to prioritize IS requirements with a business objectives driven approach. We used the GRL language to link IS requirements to business objectives. We conducted a preliminary evaluation of our method with a dozen graduate students to validate the soundness of the conceptual ingredients that underlie our approach in the context of a library loan management system.

Although this work is still at an early stage, this paper establishes guidelines to advance our long-term research project. In future research, we plan to: i) conduct experiments to validate the proposed method in a larger experimental data set, ii) support other types of dependencies between requirements in addition to technical dependencies, and iii) design and develop a comprehensive framework for automating the prioritization of IS requirements.

Acknowledgments

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