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Agile Requirements Prioritization in Practice: Results of an Industrial Survey

Aleksander Jarzębowicz*, Natalia Sitko

Department of Software Engineering, Faculty of Electronics, Telecommunications and Informatics, Gdańsk University of Technology,Gdańsk, Poland

Abstract

Agile software development stresses the importance of providing the customer with a product of a maximized business value. To achieve that, requirements prioritization is used. Agile development methods like Scrum define guidelines for prioritization, however practitioners do not necessarily have to follow them. Our goal was to investigate the industry practice related to requirements prioritization process, including its timing, participants, criteria used and prioritization techniques applied. We designed an on-line questionnaire (based on literature review) and conducted a survey involving practitioners from Polish IT industry. We received 69 valid responses indicating requirements prioritization practices in industrial Agile projects. We found out that despite the fact that business value is the most common criterion used to prioritize requirements, other criteria like complexity, stability and mutual interdependencies are considered as well. Other findings indicate that consideration of such multiple criteria requires different viewpoints, thus making requirements prioritization a process that has to involve many participants of different roles and competencies.

Keywords: Agile Requirements Engineering; Requirements Prioritization; Business Value; Value-Based Software Engineering; Survey

* Corresponding author. Tel.: +48-58-3471464; fax: +48-58-3472727;
E-mail address: olek@eti.pg.edu.pl

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1. Introduction

Software engineering is a practically-oriented field of computer science, focusing on methods of software-intensive IT systems development in an industrial context. Such context, generally speaking, includes customer-supplier relationship, where the customer is willing to pay for the software, because of its perceived value. IT systems in business applications are considered a tool for optimizing business processes and a source of competitive advantage. Delivery of actual value to the customer is however not a simple and straightforward task. The history of failures and challenges associated with IT projects led to the idea of Value-Based Software Engineering (VBSE) and to new strategies and methodologies of IT development. In particular, new approaches that support this idea, namely Agile and Lean, gained recognition and became adopted by mainstream software industry. Agile approach stresses the importance of providing the customer with a product of a maximized business value [1]. Also, one of basic elements of the emerging concept of "agile mindset" is the attitude towards customer satisfaction and needs [2]. Lean software development states that anything which does not add value for customers is considered waste [3]. One of the ways to conform to such principles is by distinguishing requirements with respect to their business value and using a prioritized list of requirements to guide development process. It is a practice adopted by particular development methods like Scrum [4] or Extreme Programming [5].

Requirements prioritization (RP), conducted in each iteration and driven by business value, was one of the first practices reported as most commonly adopted in industrial agile projects [6]. The results of adopting this practice can be observed quickly, as software developers claim that Agile demonstrates a positive influence on managing changes in requirements priorities (even in case of less experienced teams) [7]. RP is reported as a way of mitigating known challenges in requirements engineering such as: continuous management of requirements that may change over the course of the project [8] or rare customer involvement and requirements validation [9]. It is also advised as a best way to increase customer value [10]. Given that, it is not surprising that RP is an important topic, both to researchers and practitioners. Requirements negotiation and analysis (including prioritization as an essential part) is reported by recent systematic mapping study [11] as a most explored agile requirements engineering (ARE) research subject Also, practitioners consider RP with customer involvement as one of most important ARE practices [12].

Despite its importance and potential benefits, RP in Agile development is also reported as problematic task [13], affected by several challenges [14]. Business value, used as a criterion for assigning priorities, is not necessarily unambiguous. Aurum and Wohlin [15], while arguing for value-based approach in software engineering, distinguish business, product and project perspectives of value. Further works provide additional perspectives and/or refine perspectives into more detailed criteria to be considered during prioritization (e.g. [16]-[25]). In particular, developers' perspective and related criteria like: cost/effort [19][24], reuse opportunities [17], risk [20] or interdependencies between requirements [20][25] are considered. It also means that apart from the customer or Product Owner (as suggested by Agile methods), there are also others involved in RP decision-making process [20][23]. Inclusion of additional criteria and decision makers may in turn influence the timing of (re)prioritization activities. Another issue is selection of the most suitable prioritization technique to be used in a given project from the large number of available ones [23][26]. Such choice is influenced by the number and kind of criteria considered and by technique's ability to be understood and used by all involved parties.

All those aspects indicate that RP can be a complex, multi-faceted issue and can significantly differ between organizations and teams. The most interesting related question to us is: how is RP conducted in industrial practice? There is a substantial number of empirical research studies on RP [17]-[20][24][25], but all of them have rather exploratory nature and use methods like case studies, interviews or focus groups. To the best of our knowledge we are not aware of any recent survey research on RP aimed at gathering responses from a wider group of practitioners. We identified two related surveys, which however do not address the topic of RP industrial practice, but instead focus on other aspects, namely: challenges and perceived impact of value-based requirements engineering [14] and strategies used by Agile software organizations to increase customer value [10]. We thus intended to investigate this topic by conducting a survey study dedicated to the following research questions:

- RQ1: When does requirements prioritization and re-prioritization take place?
- RQ2: What criteria and techniques are applied during prioritization?
- RQ3: Who participates in prioritization tasks?

Usually, a quantitative research like a survey study is preceded by preliminary qualitative exploratory studies e.g. interviews, focus groups or case studies. In this case however, we were able to identify such studies in the available literature and utilize their results during the design of survey questionnaire.

The remainder of this paper is structured as follows. Section 2 provides an overview of related work. In Section 3 we describe the design and execution of our survey study. Study's results are presented in Section 4, followed by their discussion in Section 5. The paper is concluded in Section 6.

2. Related Work

Several studies investigating the topic of requirements prioritization (RP) and/or value-based software engineering (VBSE) can be found in the literature. We briefly present the ones most closely related to our research, some of which were used as an input to our work, as described in Section 3.1.

The most directly related work to ours are empirical studies on RP. Cao and Ramesh [6] identified RP as one of the core, commonly used practices in the early phase of Agile methods adoption by the industry. Hoff et al. [16] conducted a field survey to determine decision factors that are considered by practitioners during RP. Racheva et al. [17] confronted agile RP "best practices" from literature and industrial practice through an exploratory study in 8 companies. Other studies involving the same main authors can also be found. In [18] they developed a conceptual model systematizing the aspects considered during RP by practitioners. In [27] they determined the concepts that are important to consider for agile practitioners when (re)prioritizing agile requirements at inter-iteration time and mapped these concepts against known Agile RP techniques. Svensson et al. [19], who limited the scope of their interest to quality requirements only, conducted interviews with practitioners from 11 companies to identify prioritization techniques and criteria used by them in RP. Martakis and Daneva [25] investigated dependencies between requirements and their influence on software project activities, including RP. A study focused on large-scale outsourced Agile projects by Daneva et al. [20] used a Grounded Theory approach to analyze three projects and uncovered, among others, the importance of vendor's point of view in RP (requirements dependencies, technical debt, risks). In addition to empirical studies, secondary studies on RP are available [23][26] and provide the overview of RP practices, techniques and criteria described in the literature.

Our research is also related to VBSE and in particular to value concepts and their decomposition into more detailed factors. The importance of VBSE was stressed by Aurum and Wohlin [15], who also distinguished 3 main categories of value. This idea was further refined e.g. by Khurum et al. [21], who introduced the term of software value map; by Alahyari et al. [22], who investigated value perception by agile practitioners; and recently by Rodriguez et al. [24], who provide a summary of value factors proposed in a number of papers dedicated to VBSE.

3. Research Setting

3.1. Survey instrument

We designed an on-line questionnaire using GoogleForms service. The questionnaire was in Polish for the convenience of respondents, as we decided to invite practitioners from Polish industry (the population we were able to access, due to available contacts and communication channels). In this paper we provide English translations of questionnaire contents. The questionnaire contained some generic questions about demographic information that characterized respondent's background and working environment (without identifying him/her nor his/her employer, as the survey was anonymous). The most important questions however focused on respondent's experience concerning practices used in RP.

To formulate survey questions on RP and predefined answers the respondents could choose from, we reviewed the existing scientific literature and used concepts and practices from several papers (mostly dedicated to RP and VBSE, but to address re-prioritization also some sources about requirements changes were included). The result is not simply a super-set of all criteria, techniques and other items extracted from the literature. We confronted information from different sources. For example, there is a large set of RP techniques available [23][26], but testimonials of practitioners indicate that they do not rather use advanced, complex techniques [19]. For this reason,

we decided to select a short list of RP techniques most frequently quoted and omit the rest, especially the more advanced ones (e.g. multi-criteria decision-making algorithms [23]) as well as various collaborative games [28], which are currently gaining popularity, but it would be difficult to select representative examples among numerous games available. We acted in a similar manner in all other cases, where the number of possible answers was too high, we included items encountered in multiple sources. The questions are presented in Table 1, together with research questions they refine and with literature sources that contributed to them. All of the questions Q1-Q7 were multiple-choice questions, each was provided with a number of possible answers, but also a text field which allowed to enter other answer.

Table 1. Survey questions.

Research question	Survey question	Sources
RQ1	Q1: When does requirements prioritization take place?	[17] [27] [29]
	Q2: In which circumstances is requirements re-prioritization done?	[27] [29][30][31]
RQ2	Q3: Which aspects of requirements are considered during prioritization?	[16][17][18][19][20][22][23]
	Q4: Which prioritization technique is used?	[19][23][26][27]
RQ3	Q5: Who participates in requirements prioritization?	[16][17][20][23]
	Q6: What criteria are used to select people to participate in requirements prioritization?	[17][20][23]
	Q7: Who makes the final decision about requirements priorities?	[17][20]

3.2. Survey study

We planned a survey study based on the designed questionnaire on RP practices. It was conducted as part of a wider survey on RE practices used in agile software development projects. In this paper we focus on RP practices only, excluding other results, which were published separately. We invited industry practitioners with experience in Agile software projects to participate in the survey. No restrictions with respect to e.g. application domain nor organization type were made.

As we were not able to find any means to gather a representative sample of the investigated target population in a systematic way, we applied a non-systematic method: convenience sampling. We used social network media (LinkedIn, Facebook, GoldenLine) to invite members of Agile interest groups and to identify practitioners fitting respondent's profile (based on their CVs), who received direct invitations. Moreover, e-mail invitations were sent to our contacts from the IT industry.

3.3. Validity procedures

We decided to conduct the survey in an anonymous manner to minimize the threat related to respondents' honesty, but still we included several demographics questions to establish the context of respondents' work.

We defined the minimal criteria to include a response in our further analyses. To minimize the threat related to the participation of people without sufficient knowledge, we decided that only respondents with actual industrial experience in Agile development (not experience from e.g. student capstone projects) would be included. Moreover, we decided that only complete responses (i.e. all questions answered) would be taken into further consideration.

We made an effort to define survey questions and answers on the basis of literature analysis, but still we were aware that some respondents might not find any of predefined answers as applicable. To address this, in each of Q1-Q7 questions we included "Other" option with opportunity to manually enter the answer.

The questionnaire was reviewed and edited several times to improve its understandability and assure compliance to guidelines [32]. A pilot study involving 3 practitioners (fitting respondent's profile) was conducted as a final test.

4. Results

The survey was conducted within the period of April-June 2018. We received 73 responses, but after checking them against the pre-defined criteria (completeness, actual industrial experience) we had to reject 4 of them. As result, 69 responses were included in the results and completion rate of the survey was calculated as 95%.

The most essential information on respondents' background is shown in Table 2. About half of them had a limited experience (less than 2 years), roughly 40% declared experience between 2 and 5 years and only a small group claimed more than 5 years in agile development. The most popular agile software development method turned out to be Scrum, either used exclusively or together with Kanban. As for job position/project role, about half of respondents identified themselves as developers (which is the most common role in Agile teams). About 40% declared that they work as Product Owners (POs) or analysts. It seems to confirm testimonials from the industry that, despite lack of explicit identification of analyst's role in Agile methods e.g. Scrum, in practice it is not uncommon to apply Agile software development together with an explicit activity of requirements engineering and/or business analysis and to designate a development team member(s) responsible for this activity [33][34]. Such share of POs/analysts in our sample is probably much larger than in the target population (Agile practitioners in Polish IT industry). The possible reason is that POs/analysts were the ones mostly interested in the survey on ARE. It does not have to be considered a drawback, as POs/analysts can be considered as practitioners most knowledgeable about requirements development and management in their projects. As for results regarding RP practices, we present it below, grouped by research questions they address.

Table 2. Demographic information about respondents.

Answer	No. of responses	% of responses
Experience in agile software development:		
Less than 2 years	36	52,2%
2 – 5 years	28	40,6%
5 – 10 years	3	4,3%
More than 10 years	2	2,9%
Agile method used:		
Scrum	47	68,1%
Kanban	3	4,3%
Scrum and Kanban	18	26,1%
Other	1	1,4%
Job position / project role:		
Developer	34	49,3%
Analyst / Product Owner	28	40,5%
Tester	2	2,9%
Other	5	7,2%

RQ1 - *When does requirements prioritization and re-prioritization take place?*

RQ1 was addressed by Q1 and Q2. Fig. 1a shows answers for Q1 (When does requirements prioritization take place?). Almost three quarters of respondents (51) claim that RP is done at planning meetings preceding a sprint or an iteration. However, in 27 cases, RP takes place during sprint or iteration. RP done at the beginning of the project is experienced by 21 of respondents. The remaining (free text) answers indicated that RP is a response to events like new requirements or bug reports.

When RP is done multiple times (e.g. before and during a given iteration), there can be several reasons for re-prioritization. The related answers are depicted in Fig. 1b. The most common answer (50) is change in requirements, followed by similar values of change in project scope (38) and change in business goals (37). Changes affecting project constraints (schedule, budget) are reported as causes for re-prioritization by less than half participants (28

and 25 respectively). Other answers included: reactions to problems with delivering sprint's scope and bugs reports received.

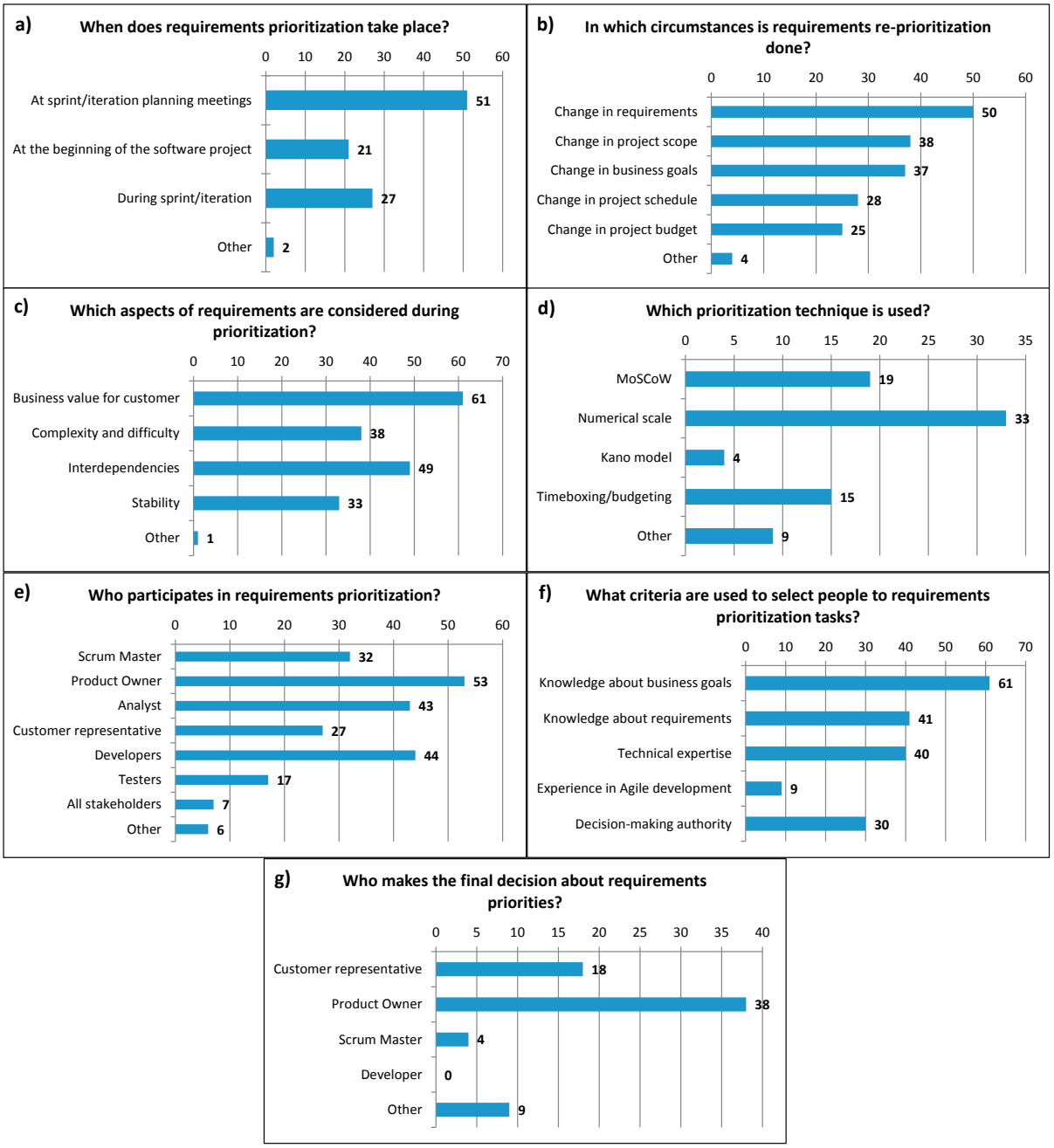

Fig. 1. Distribution of answers to all survey questions: a) Q1; b) Q2; c) Q3; d) Q4; e) Q5; f) Q6; g) Q7.

RQ2 - *What criteria and techniques are applied during prioritization?*

Fig. 1c shows answers to Q3 regarding the aspects of requirements that are considered during prioritization. The vast majority of respondents (not all though - 61) declared that business value for the customer is a criterion considered in RP. The next aspect are interdependencies between requirements which are important to about 70% of

respondents (49). Complexity of requirements and perceived difficulty of implementation were declared by 38 respondents and requirements stability (i.e. what is the likelihood that they could change) by 33. One respondent reported dependency on third parties as an additional criterion.

As for prioritization techniques we asked about in Q4, the results are depicted in Fig. 1d. The most popular approach seems to be usage of simple numerical scales (assigning each requirement with a number from a predefined scale - e.g. 1-5, where the higher number means the more important requirement). This technique is however declared by less than a half of respondents (33). The recently popular MoSCoW technique is less common (19). Timeboxing/budgeting was declared by 15 respondents only. Kano model, which is suggested for Agile projects by e.g. BABOK Guide [35] and its extensions is seldom used - 4 answers only). As for "other" answers, most of them pointed to simple ordering of backlog or other kind of requirements list, without using any categories nor values assigned to requirements.

RQ3 - *Who participates in prioritization tasks?*

The first question from this group (Q5) was about roles participating in RP. As shown in Fig. 1e, the most frequent answer was Product Owner (53). Scrum Master was reported as RP participant by less than a half of respondents (32). In 43 cases analysts were mentioned, which seems to confirm the observable tendency of including such role in Agile projects, despite the fact it is not explicitly defined in popular Agile methods. Other team members that can also participate in RP are developers (44) and testers (17), which is consistent with Q3 answers indicating that technical point of view (interdependencies, implementation difficulty) is represented when prioritizing requirements. Quite often (27) a customer representative is directly involved, in some cases it is not a single representative but all relevant stakeholders (7). In addition, respondents who entered their own answers, mentioned managers (5) and software architect (1).

Fig. 1f presents answers to Q6, which purpose was to determine the criteria used to select participants of RP tasks. The most common answer was the knowledge about business goals (61), but also other criteria gained significant numbers of responses, namely: knowledge about requirements (41) and technical expertise (40). Decision-making authority was considered by less than half participants (30), while experience in Agile development was rarely considered (9).

The last question (Q7) was about the person who makes final decisions about priorities. As shown in Fig. 1g, most of participants assigned this authority to Product Owner (38), which is in line with Scrum guidelines. In 18 cases such decision is made explicitly by customer representatives. Scrum Master was mentioned by 4 respondents, which shows serious discrepancies to the original Scrum method. Developers do not make final decisions about priorities, not in a single case. As for "other" answers, managers (4), analysts (4) and architect (1) were reported.

5. Discussion

In this section we discuss the most important results and we consider possible threats to validity of our study.

5.1. Observations

The answers to Q1 question were submitted to a more detailed analysis. As shown in Fig. 1a, the most common answer was that RP is done at the beginning of the sprint/iteration. In 29 cases, it was the sole answer of the respondent to this question, while 19 participants declared using RP at the beginning of sprint/iteration and later during the occurrence of sprint/iteration. This suggests that RP is mostly applied before each iteration, but can be followed by re-prioritization as the iteration is already in progress. As for RP at the beginning of the project, the patterns in answers indicate that it is rather an initial attempt, later reinforced by RP conducted before or during iterations, however in 6 cases this was the only answer selected by a respondent.

Re-prioritization that e.g. takes place during iteration can be triggered by changes in requirements or more general changes (business goals or project scope). Changes to budget or schedule constraints are not as often reported as re-prioritization cause.

With respect to RP techniques, our respondents seem to rely on simple techniques like numerical scale or MoSCoW. A more sophisticated Kano Model is seldom used in participants' teams. It seems to confirm the earlier observations by [19]. Quite surprisingly, timeboxing/budgeting, which fits well into Agile philosophy, was explicit-

ly declared by few respondents, which may indicate that estimation of requirements' complexity and work effort is not a wide-spread practice.

As for prioritization criteria, business value was reported as most important, but other aspects (dependencies, complexity, stability) are considered as well by many organizations/teams. It is also reinforced by answers to other questions. In Q5 the results indicate that RP often involves analysts, developers and testers and in Q6 that criteria to select people to RP tasks include knowledge about requirements (analysts) and technical expertise (developers). It seems consistent with findings reported by others, including: [16][17][19][20][25]. Our survey also revealed that project managers or other management staff influence prioritization. We have not even include them as predefined answer, given the principle that Agile teams are supposed to be autonomous and self-organizing. However, looks like in practice managers overseeing Agile software projects are not uncommon. The final decision belongs however to PO or customer representative.

Some results were quite surprising with the respect to the principles and guidelines of Agile methods, in particular Scrum, which turned out to be the most commonly used method by survey participants. For example, it seems that in some Scrum teams the Product Owner is not involved in RP, which clearly conflicts this role's clear responsibility for Product Backlog. Moreover, Scrum Master was reported as RP participant by less than a half of respondents, despite the fact that Scrum Guide [4] assigns several responsibilities to this role, including: finding techniques for effective Product Backlog management and helping Product Owner to arrange the Product Backlog to maximize value. Another such surprising observation is conducting RP at the beginning of the project only. Such results may indicate that industry uses specific adaptations of Scrum, possibly even the ones that violate basic principles of this method, which is an unfortunate but observed behavior [36]. It is not possible though to definitely claim so on the basis of this survey data, this could be addressed by a separate research study.

5.2. Threats to validity

Despite following validity procedures described in Section 3.3, several limitations and threats to validity have to be documented.

Internal validity: We used a non-random selection of survey respondents (by social media interest groups and by direct contacts), which could introduce additional unknown variables. Dissemination through social media groups is a channel that prevents us to determine how many people received our invitations. It also included an element of self-selection – we were not in any way able to force them to fill the questionnaire, thus it relied on individual decision to participate. Also, we are aware of an inherent threat to questionnaire survey research that answers are participants' subjective views and can be biased.

External validity: The most relevant threats from this category are: the number of participants, their heterogeneity and the fact that they were all from a single country. The relatively small number and some observations regarding participants' demographics (e.g. significant share of analysts and Product Owners) suggest that, despite out efforts to reach people from various company types and application domains, it is hard to ensure that our sample is representative for the whole population. And even if it is representative for Polish IT industry, there can be differences between different countries. The limited experience of significant part of respondents can also be considered a threat, however the survey questions mostly concerned facts related to their work and did not require significant expertise (which would surely be a prerequisite if we asked about e.g. effectiveness of methods or practices).

Construct validity: This survey research is associated with mono-method bias, as our only source of data are the answers of survey participants. By making anonymous survey, we tried to minimize threats of guessing answers and providing false, "better-looking" answers, but we cannot totally exclude such possibilities. Also, the questionnaire was based of literature sources (which allows to argue that constructs used were sufficiently defined), but its design included decisions that were at least partially subjective (e.g. final selection of a pre-defined answers).

6. Conclusions

Requirements prioritization is an important task, having impact on subsequent software development activities. This paper provides an update on how RP is done in practice on the basis of survey responses gathered from 69 IT

industry practitioners. As RP is an activity directly contributing to business value delivery, it is important to identify its current state of practice, based on industrial evidence. The findings of this paper can be used by practitioners to make decisions about RP activities for IT projects they participate in and by researchers to plan more focused studies investigating the causes and contextual factors behind the practices declared by our respondents.

Regarding RQ1, the results show that RP is mostly conducted before each iteration, only some cases require re-prioritizing during the iteration and the main causes for re-prioritization are changes that redefine previously elicited requirements, while changes to business goals and project scope occur less frequently. As for RQ2, our results confirm the primary importance of business value associated with particular requirements, but at the same time show significant importance of aspects essential from vendor's point of view like requirements interdependencies, complexity and stability. Simple RP techniques, not requiring advanced competencies like numerical scales are most commonly used. Regarding RQ3, the results show that apart customer's point of view and focusing on business value, the participation of vendor's representatives is common. Such representatives are selected due to their particular roles in the development team and/or competencies like technical expertise or knowledge about requirements.

The possible future work includes a more in-depth analysis of rationales behind RP practices used and their consequences, using other research methods e.g. case studies. In particular, reported practices that potentially conflict with guidelines of Agile methods seem to be an interesting research direction.

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