Validation of RP-SPF Framework: A Systematic Method for Requirements Reuse in Software Product Lines

Badamasi Imam Ya'u , Azlin Nordin, Norsaremah Salleh

Abstract: Reuse of requirements is crucial activity in software development especially across software product line engineering (SPLE), which involves two main processes known as domain engineering and application engineering. With these two processes SPLE enables systematic reuse of requirements through proper planning and development. This paper presents methodology and result of survey of experts for validating a proposed systematic requirement reuse approach named requirements pattern for software product families (RP-SPF) framework. During the survey, 14 experts in requirements engineering (RE), SPLE and software development responded and gave their opinions on RP-SPF framework. The result of the survey shows that RP-SPF approach is suitable and can effectively improve requirements engineering activities of SPLE.

Keywords: Software Product Line Engineering, Requirements Pattern, Systematic Requirements Reuse, Expert Validation.

I. INTRODUCTION

The main goal of software engineering (SE) is production of quality software products within project schedule and organization budget. To achieve these 3 project management success criteria, reuse of software requirements offers potential benefits to improving software quality, truncating development cost and time to market (Benitti & Silva, 2013; Chernak, 2012; Goldin & Berry, 2013; Ya'u, Nordin, & Salleh, 2018; Ya'u, Nordin, Salleh, & Aliyu, 2018).Furthermore, literature shows that, the benefits of requirements reuse is not confined to requirements at higher level only but also descends down lower levels of software developments (Goldin, Matalon-Beck, & Lapid-Maoz, 2010; Srivastava, 2013). This gives upper to practitioners to equally reuse requirements arte facts in design, coding and testing (Bakar & Kasirun, 2014; Liang, Avgeriou, & Wang, 2011). The main contribution of this paper is presenting the result of validation of systematic requirements reuse framework (RP-SPF) from experts' opinions. The remainder of the paper presents overview of RP-SPF framework in Section 2. Section 3 presents the methodology followed during the validation of this approach. Result of the survey is presented in Section 4. The discussion of the result is presented in Section 5. Finally, Section 6 summarizes the paper.

II. OVERVIEW OF RP-SPF FRAMEWORK

This section describes the proposed framework of this research, which is RP-SPF (requirements pattern for software product families). RP-SPF is a general framework developed for systematic requirements reuse in software product line engineering (SPLE). Thus, RP-SPF framework incorporates the concepts of *design for reuse* and *design with reuse* at domain engineering and application engineering of SPLE respectively (Pohl, Böckle, & van Der Linden, 2005; Ya'u, Nordin, Salleh, et al., 2018). To achieve systematic requirements reuse, RP-SPF merges requirements pattern approach, traceability and variability management of requirements through the principles and guidelines of requirements engineering (RE), SPLE and model-driven engineering (MDE).

III. RESEARCH METHODOLOGY

Research objective and questions of the survey

The purpose of this survey of expert opinion is to achieve the stated objectives through the research questions of the survey. Table lists the survey objectives and research questions.

Table. 1 Research objectives and questions of the survey

Objectives	Research Questions
1. To evaluate the suitability and applicability of RP-SPF in software product line requirements engineering activities 2. To evaluate the effectiveness of RP-SPF concerning requirements reuse in software product line.	1. Does RP-SPF suitable and applicable in the requirement engineering of software product family? 2. How effective is RP-SPF approach on requirements reuse in software product line engineering?

Design and development of survey instrumentation

The survey instrument used for the purpose of collecting data is online questionnaire using Google form. The Questionnaire was developed and organized into three sections, which are Sections A for expert demographic, B for main validation questions and C for general validation questions.

Revised Manuscript Received on September 22, 2019.
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Measurement scale

This research uses 5-point Likert scale constituting "Strongly disagree = 1", "Disagree = 2", "Neutral = 3", "Agree = 4", and "Strongly agree = 5" for measuring the responses to the questionnaire items.

RP-SPF constructs

The development of the questionnaire used for this survey constitutes a number of constructs and categories representing concepts and factors elaborated in the literature that enhance and facilitate systematic requirements reuse. Based on the results of the literature review and the objectives of the survey, the questionnaire consists of 3 main constructs, which are: (1) reuse of requirements (2) requirements pattern in SPLE and (3) metamodeling.

Data analysis procedure

The collected quantitative data from the survey in this research were computed in the statistical software tool, SPSS Version 21.

Furthermore, since the survey questionnaire consists of open-ended questions for collecting further suggestions, opinion and recommendation, additional qualitative data analysis was performed.

Reliability testing Cronbach's alpha

Reliability test was run on the instrument to check the internal consistency between the items. The result of the reliability analysis was presented in Table.

Table. 2 Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.853	.851	17

According to (Robinson, Shaver, & Wrightsman, 1991), the value of Cronbach's alpha must reach .7 and above for the result of the analysis to be accepted. Hence, from the on tabulated result, it shows that the instrument was reliable as the value of Cronbach's alpha was above .7, that is .853.

Expert demographic

A total of 14 experts responded to this survey. Table presents description of years of experience of experts in RE, which shows that 50% of the experts acquire more than 10-year experience in RE. This indicates that level of experience of the experts gives confidence of whatever opinion the experts would express.

Table. 3 Requirements engineering experience

	Year	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 3	2	14.3	14.3	14.3
	4-5	1	7.1	7.1	21.4
	6-10	4	28.6	28.6	50.0
	More than 10	7	50.0	50.0	100.0
	Total	14	100.0	100.0	

IV. RESULTS

This section presents the results of the survey of this research, which include result of the descriptive statistics of the closed-ended questions of the instrument (quantitative part) and analysis of the open-ended responses (qualitative part).

Descriptive statistics

This subsection presents descriptive statistics of the 17 questionnaire items that the experts responded quantitively using 5-likert scale ranging from strongly disagree (1) to strongly agree (5). To answer the research questions in Table, we take into cognizance the result of the responses presented in Table. From the scores of Medians in the Table, the median value for all items ranges from 4.00 to 5.00 corresponding to agree and strongly agree taking into consideration the 5-Likert scale. This shows that the 14 experts were in agreement with every single item of the questionnaire. Thus, it can be concluded that RP-SPF framework is suitable to be implemented in requirements engineering activities of software product line engineering (SPLE). Furthermore, RP-SPF framework could be effective for enhancing and achieving systematic requirements reuse in SPLE.

Table. 4 Descriptive statistics for questionnaire items

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
N	Valid	14	14	14	14	14	14	14	14
	Missing	0	0	0	0	0	0	0	0
Mean		4.07	4.14	4.21	4.36	4.29	4.14	4.29	4.50
Median		4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.50

		Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
N	Valid	14	14	14	14	14	14	14	14	14
	Missing	0	0	0	0	0	0	0	0	0
Mean		4.50	4.29	4.07	4.00	4.07	3.71	3.64	4.36	4.14
Median		5.00	4.00	4.00	4.00	4.00	4.00	4.00	4.50	4.00

Open-ended questions

From the total number of 14 experts participated in this survey, 8 experts representing 57.1% responded to both closed-ended and their corresponding open-ended parts of the questionnaire. However, 6 experts representing 42.9% responded to the closed-ended questions of the questionnaire only. Furthermore, the 8 experts as demonstrated by

Fig skipped the open-ended parts of 4 questions (Q12, Q15, Q16 and Q17). This might be due fairness the experts wanted to do to those questions to avoid been bias in responding to them or answering them wrongly.

During content analysis of the open-ended responses, this research categorize responses of the experts based on a coding scheme found in (Kay & Knaack, 2009). From the responses to 13 open-ended questions that support the closes ended questions, 31 category codes were formed with total number of 45 responses from the experts.

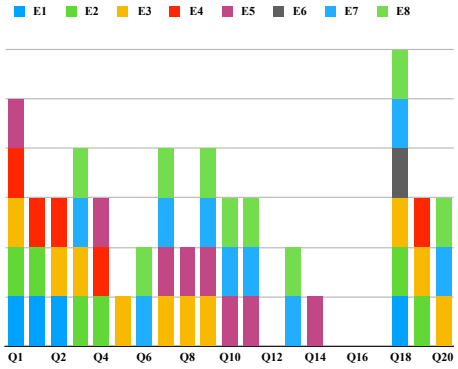

Fig. 1 Open-ended questions responded by experts

The reposes were rated on a 5-point Likert scale (-2 = very negative, -1 = negative, 0 = neutral, 1 = positive, 2 = very positive) (Kay & Knaack, 2009). The overall result shows that from 45 responses, 39 representing 87% were positive. This means that only 6 representing 13% were negative. Therefore, the data for the open-ended part supported the result of the close-ended part of the instrument.

Furthermore, for the last 3 questions of the instruments (Q18, Q19 and Q20), which have no close-ended parts, the experts also gave positive feedback and recommendation to improve RP-SPF framework.

Overall analysis of the open-ended questions shows that RP-SPF framework is suitable and effective for enhancing and achieving systematic requirements reuse in SPLE.

V. DISCUSSION

To answer the research questions of this survey, Section 4 presents the results of the survey, which shows that majority of the responses in both quantitative and qualitative data were positive. Exemplifying with Figure 2, which depicts expert's responses to questions 3 and 4 of the instrument; the result shows strong agreements as the responses fall between 4 (agree) and 5 (strongly agree) only. This indicates that RP-SPF framework can provide a reusable structure for systematic requirements reuse that can also yield quality software products.

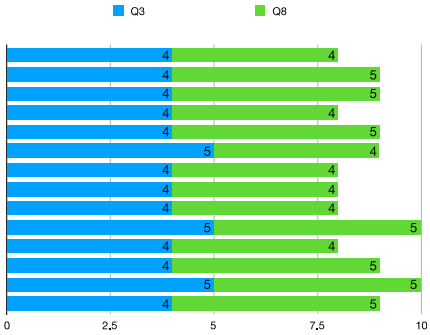

Fig. 2 Experts showing strong agreement

Furthermore, the result of the responses for questions 7, 15 and 17 shows a mixture of levels of agreements, which include even 2 (disagree) and 3 (neutral). As described by Fig, each of these items has been responded with at least disagree, neutral or both. However, this is not detrimental to the overall responses on the items. For instance, the result shows that only 1 expert disagrees with the item (Q7) with less than 10%. Thus, the aggregate of the level of agreement with other experts is greater than 90%. This indicates that the explicit documentation provided by RP-SPF can improve communication among stakeholders in software product lines.

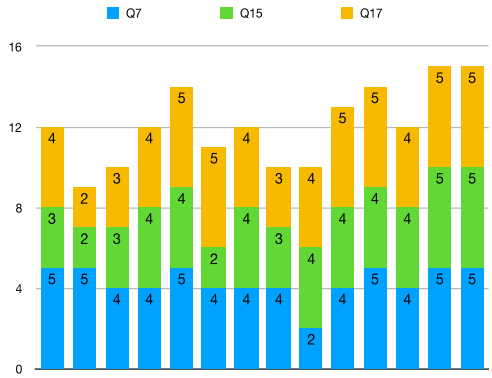

Fig. 3 Items with disagreement responses

Analogously, 2 experts responded to item 15 of the questionnaire with disagree while 3 experts with neutral. The aggregate shows the level of the agreement for the rest of the experts is greater than 60%, which indicates that unavailability of the requirements pattern repositories is a limiting factor for practitioners to use. Thus, there is need for available requirements pattern repository as included in RP-SPF framework. In the manner, it shows that aggregate responses to item 17 from 3 experts showing disagreement and been neutral is 21.4%. In the other hand, 11 experts show high level of agreement with the item representing more than 78% on an aggregate.

Thus, it can be concluded that lack of awareness plays a significant role in preventing practitioners to use requirements pattern approach.In obtaining such results, this paper contributes to knowledge and practice of RE and SPLE by presenting the evidence of experts' validation of the proposed systematic requirements reuse framework (RP-SPF).

Threat to validity

The main sources of threat to validity of this survey are internal and external validity. For the internal validity, the constructs used for the development of the instrument are not based on existing theories and tested models, thus this might affect the validity of the instruments. However, the research uses existing concepts reported in the literature as factors that support systematic requirements reuse. For this reason, the instrument was constructed to gather opinion of experts in validating RP-SPF framework. Prior to final data collection, the instrument was validated by 5 experts (PhD holders) at International Islamic University Malaysis, followed pilot testing with 5 PhD students in the same university.

Furthermore, the sample size of the repondents might also effect external validity in terms of reliability of the instrument and final result of the survey. Nevertheless, research shows that even small sample size such as 4 can yield acceptable Cronbach's Alpha value (Bujang, Omar, & Baharum, 2018). In this survey, our sample size is 14 and the number of items is 20, and thus the Cronbach's Alpha value is 0.853, which is even greatern than the accepTable value (0.7).

VI. CONCLUSION

This paper presents research methodology and result of survey of expert's validation of proposed systematic requirements reuse framework (RP-SPF). In this research, a 5-point Likert scale instrument consists of both close-ended (quantitative) and open-ended (qualitative) parts was designed, validated and distributed online to more than 60 experts in requirements engineering, software product line engineering and software development. Subsequently, 14 experts responded within 4-5 months. The results of analysis for both quantitative and qualitative data of the distributed instrument answered the research questions and supported the objectives of the survey in terms of suitability and effectiveness of RP-SPF framework in improving requirements engineering of software product line engineering. We are currently preparing to conduct experiments with requirements engineering students in a university to evaluate the approach using RP-SPF tool in comparison with ad hoc approach to requirements reuse and documentation.

ACKNOWLEDGMENT

This research was funded by the Ministry of Higher Education Malaysia under FRGS research grant (FRGS/1/2018/ICT01/UIAM/02/2).

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