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Pair in Software Requirements Engineering: A Review

Ow Li Lee, Massila Kamalrudin and Safiah Sidek

Abstract
Requirements engineering (RE) is a crucial activity in software development. This is because requirements provided by client-stakeholders need to be at high quality to ensure the success of a software project. It is also identified that most faults are originated from requirements and mostly due to ineffective communication between both the requirements engineers and client-stakeholders. Resulted from this issue, a more comprehensive approach to improve the communication and discussion such as pair, peer, group and collaborative are introduced in each phase of the RE activities. To study further on the adoption of these approaches in RE activities, we have conducted a review on the existing works that implemented pair, peer, group and collaborative concept in RE. We have synthesized and summarized the approaches and focus related to each of the RE activities. Finally, we found that that the existing implementation of pair concept in RE is able to improve the communication between the requirements engineers and client-stakeholders as well as improve the quality of requirements.

Keywords: Software Requirements Engineering activities, Pair, Peer, Group and Collaborative

1.0 Introduction

Requirement engineering (RE) plays a significant role in determining the quality of software development and it is recognized as the most critical and complex stage in software development. RE comprises of four main stages that are requirements elicitation, requirement requirements analysis and validation, requirements documentation and requirements management [1]. RE is also an intensive human centric activity that requires active interaction between requirements engineers and client-stakeholders. Many have claimed that issues, such as low quality of requirements, missing requirements, requirements defects, requirements inconsistency and incompleteness are resulted from miscommunication, misinterpretation and conflict between both parties. This is because ineffective communication and code switching [2] between both parties occurs.

Considering that effective communication between the two parties is crucial for the production of quality requirements, method or techniques such as collaborative, group, pair and peer discussion are required for gaining quality requirements. However, the usage of those methods is less emphasize in the current IT practices. Therefore, the purpose of this paper is to investigate the methods and techniques of pair, peer, group and collaboration in requirements engineering (RE) activities. The remainder of this paper is structured as follows: Section II describes the background and Section III portrays the research methodology. Section IV elaborates on related works and Section V presents our results and findings from the literature review. Conclusion is presented in Section VI.

2.0 Background

2.1 Pair Concept

Pair is define as two people, standing or doing somethings together or have some types of connection with each other [3]. Pair concept has rigorously used in extreme programming, called as pair programming. Pair programming is a style of programming whereby two programmers sit side-by-side at one computer, continuously and simultaneously collaborating on the same design, algorithm, code or test. One of the pair called as driver, who writes down a design and creates codes at the computer, and the other one called navigator, who observes and reviews the driver's work and looks for defects. The driver and the navigator are continuously engaged to brainstorm a solution. The roles between the driver and navigator are swapped periodically [4][5]. The focus in pair programming is the role of driver and the navigator. They are assigned with specified roles and tasks to avoid overlap production and to detect defects while executing. Most importantly, the continuous and constant review and checking from the navigator is proven as a contribution in the quality of the system developed.

2.2 Software Requirements Engineering Activities

This section aims to describe the activities involved in requirement engineering and highlight the significance of adopting pair work in requirement engineering for the production of quality software. RE refers to the use of systematic and iterative techniques to ensure the requirement consistency, completeness and relevance to the system developed. The important role played by RE as a team player within software development life cycle has been recognized and established by researcher long time ago. Requirements are pervasive to affect the continuous activity throughout the whole development process. An overview of activities involved in requirement engineering is presented in Figure 1. Based on Figure 1, there are four main activities encompassed in RE, which are i) Requirement elicitation, ii) Requirement analysis and validation, iii) requirements documentation and iv) requirements management. Although these activities are conducted in sequence, they are dependable to each other. In other words, a weak elicitation or analysis may lead to poor quality of requirements.

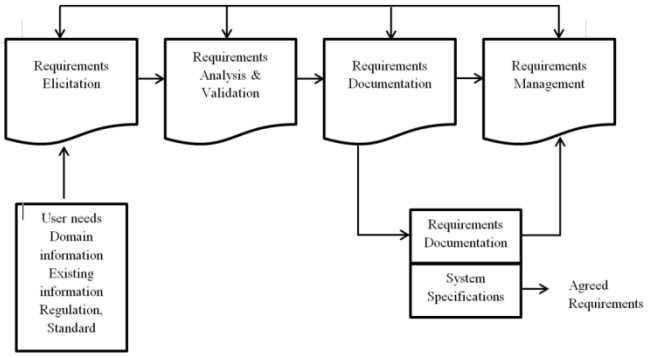

Figure 1: Software Requirement Engineering Activities [6]

The first activity in RE is the requirement elicitation. The objective of this activity is for the stakeholder to communicate their expectations and needs for the development of a system. This is the stage where both the requirements engineers and the stakeholders need to have active discussion or two-way communication. This is the most crucial stage in software development since the requirements elicited will be used through-out the development process. At this stage, the stakeholders' needs and system constraints will be discovered, discussed, reviewed and documented. The requirements engineers need to fully understand the problems and needs of the stakeholders. Typically during the discussion, the stakeholders do not have any idea on the system requirements nor the capability of the system. On the other hand, the requirement engineers do not understand the problem raised or encountered by the users. Requirement elicitation process is indeed important to ensure the developers develop the right system to satisfy the expectation from the stakeholders. Trade-offs need to be done between requirement engineers and stakeholders to compromise on the requirements gathered during the requirement elicitation stage.

Once the requirements elicitation is conducted, the second activity is the requirement analysis and validation. The objective of this activity is to check, filter and define the high level of requirements by into clear, complete, consistent and stakeholders approved requirements. Review and cross checking is carried out between the stakeholders and requirement engineers. The stakeholders' needs and constraints are validated, refined and filtered at this stage. Requirement analysis and validation enables the requirement engineers to detect and resolve the conflict between requirements raised by the stakeholders by discovering the boundaries or capabilities of the system. A large volume of unnecessary, vague, ambiguity requirements elicited during the first stage will be classified and well allocated.

The third stage of RE is requirement documentation. Requirement documentation defines what and how the system will be developed by recording all the agreed functional and non-functional requirements. The purpose of developing the project will be included in requirement document as well to keep the team works on the right track.

The last activity in RE is requirements management where the requirements are coordinated, scheduled and documented. The requirements are managed and traceable in requirement management to coop with any changes on the requirements. Traceability features in requirement management, for example version for requirement changes, is vital for effective requirement management. Requirement changes might be due to the reason of business process change, change of stakeholders, better understanding of the system or additional features to be added.

3.0 Research Methodology

The aim of this review is to investigate the adoption of pair work in requirements engineering. This review considers the concept of pair as activities involving more than one party working together at the various stages of activities in the requirement engineering. In this case, besides pair work, collaborative, group and peer at the various stages of activities in requirement engineering were included in the investigation. Intensive research has been conducted to improve the quality of requirements from the different stages of activities in RE. Performing a proper and suitable RE process has an impact on the continuum software development and the quality of the system being developed. Thus, we would like to investigate the application of pair concept in each of the RE activities. We have conducted a review on existing work focusing on the pair concept in requirements engineering. This review aims to collect the application of pair/ collaborative/ group/ peer concept in requirements engineering. The following procedure was conducted as shown as Figure 2 to ensure that relevant literatures are included in the analysis.

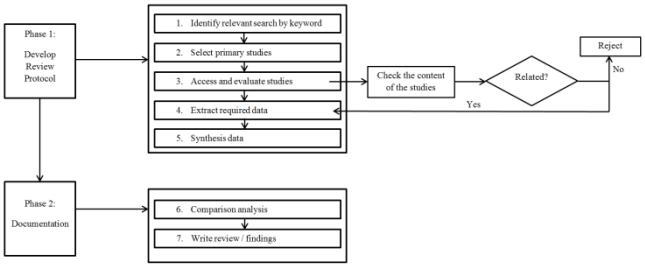

Figure 2: Review Protocol

Based on the review protocol shown in Figure 2, there are two phases included for our literature search. In phase 1, a review protocol was formulated and developed specified to our literature search in the field of requirements engineering. The empirical studies were search by using search engine like SCOPUS, IEEE xplore, ACM, ELSEVIER and Google Scholar database. The search keyword used were "requirements engineering" / "requirements elicitation" / "requirements analysis and validation" / "requirements documentation" / "requirements management" + "pair" / "peer" / "collaborative" / "group" to ensure all related the papers are included. As the initial search based on the keyword "pair in requirement engineering" has resulted 731 million papers. By examining the title and abstract of the primary identified studies, we had excluded most of the paper due to irrelevant topic found in the studies. There are 50 studies during the second activity of selecting primary studies

similar to our domain of content. At the third process, we accessed and evaluated the studies by checking the content of the studies. Irrelevant studies will be rejected at this stage and on the hand the relevant studies will be examined further. Out of 50 papers, there are only 12 papers found similar to our content of reviewing. Next, the following data were extracted from the 12 papers: i) the objectives, ii) methodology of the studies, and iii) the results presented. The extracted data were carefully studied to filter and distil possible overlaps. The synthesized data resulted in a consolidated section of related works in Section 4 below.

In phase 2, we classify the extracted data into tables of comparison, as shown in Section 5. Different types of methodology are classified accordingly to different types of implementation like pair, collaboration, group and peer concept. In addition, the extracted objectives from 12 studies are also categorized into a comparison table. Last but not least, we reported our findings based on our literature search in this review paper.

3.1 Collaborative

There is one established attempt for collaborative requirements negotiation named WinWin approach originated from the author Boehm [7]. The WinWin model aims to negotiate a set of mutually satisfactory of agreements among stakeholders that served as the foundations to requirements, constraints and project's plans. The WinWin model provides a well-defined structure and a process to negotiate requirements. The negotiation process on requirements supports collaboration among stakeholders by encouraging the participation of the stakeholders in WinWin system. However, the WinWin has been improved and evolved to the latest version, EasyWinWin (EWW). EWW [8] defines a set of activities guiding stakeholders based on a process of gathering, elaborating, prioritizing and negotiating requirements. EWW differs from WinWin whereby it does not aim at rigid agreements and detail of requirements specifications but rather involve the stakeholders with a shared vision and common belief in order to react to unpredictable problems in an adaptive and quick manner. EWW negotiation model provides the capture, representation and usage of rationale. Rationale is captured based on process of communication and negotiation of stakeholders. This increase collaboration and coordination within group awareness and support requirements trade-off analysis. The relatively high complexity aggregates the major drawback of this approach since both the moderates and participants need to be well-trained.

Geisser and Hildenbrand introduce CoREA method [9] for collaborative requirements elicitation cater for distributed environment as well as quantitative decision support for requirements prioritization and selection. CoREA is built upon EWW with different techniques used. It consists of two distinct phases, the iterative and collaborative requirements elicitation and analyzing on the cost and value of the respective requirements. The three works mentioned above from WinWin, EWW to CoREA propagate changes from the traditional oriented mechanism to a collaborative practice based on the trustful relationship among the stakeholders.

Laporti et al. proposed Athena, an collaborative approach established on collective knowledge to collect system requirement based on a narrative use stories to the definition of use cases [10]. This approached proposed intended to substitute the traditional ways of interviews and surveys during requirement elicitation. The approach was divided into two components; a method based on group storytelling and activity theory on building of use case diagram. Laporti et al. employed the advantages of grouping in requirement elicitation phase whereby there is someone in the group as a second opinion. The proposed framework has yet to be evaluated in any forms of experiments. There is still no significant result to prove the proposed collaborative approach aids in requirement elicitation process.

Another study has been conducted by Azadegan et al.[11], they presented a collaborative process for user requirements elicitation in a facilitated collaboration environment. They adopted the principle of Collaborative Engineering to requirement elicitation activity which consists of ThinkLets as their building blocks. They aimed to guide the stakeholders in a collaborative manner through a decision making process. However, their approach was evaluated in China by using solely Chinese language.

The two propose approaches [11] [12] above were conducted in a collaborative environment which were found to be similar to pair concept whereby the requirement elicitation process was facilitated by another person or a group during the process.

3.2Group

In addition, Focus Group Discussion is a facilitated brainstorming and discussion technique available which found similar to collaboration work. It is a less formal techniques for discussion compared to a formal meeting. Zarinah and Siti incorporated Focus Group Discussion techniques and proposed FGD-RElicit[12] to support for requirements elicitation. FGD-RElicit put the stakeholders to work collaboratively by giving rationale to their viewpoints and concerns before making decision for system requirements. FGD-RElicit is a multi-viewpoint tool enabling the stakeholders to share and suggest on requirements. The multi-viewpoint of requirements will be identified, elaborated, and lastly integrated. FGD-RElicit tool supports the collaborative nature in requirement engineering and achieves mutual understanding among stakeholders. Focus Group Discussion technique is believed to be beneficial as a better requirements elicitation compared to traditional techniques which is usually individual work.

On the other hand, groupware is another technique found to be in the similar context of collaboration. Researchers Lloyd, Rosson and Arthur investigate on the effectiveness of elicitation techniques in distributed requirement engineering and reported on how groupware (software for collaboration) aids in requirement engineering [13]. In their distributed requirements engineering experiment, groupware appeared to produce a higher quality of SRS requirements document. They perceived group mates contribute in producing higher quality of requirements document.

3.3 Pair

Scnniello and Erra assessed a new method based on think-pair-square in the distributed constructing of use case diagrams [14]. They believed think-pair-square tool promotes active learning and collaborative discussion during the process of modelling use case diagrams. Think-pair-square method has been applied in the field of requirement engineering to solve problems in a cooperative way. They aimed to investigate the effectiveness of their proposed think-pair-square tool with the traditional face to face requirement elicitation. The participants in the case study were found to spend significantly less time in use case modelling. This work is believed to be beneficial to improve requirement elicitation process by promoting active learning and collaborative discussion among members. However, think-pair-square method only focuses on English requirements and does not cater for multi-lingual requirement elicitation.

Based on the literature search, researchers are found to put effort to improve the quality of requirements by focus in the other activities of RE. Albakry and Kamalrudin employed the paradigm of pair concept into requirement analysis phase and named it as pair analysis [15]. They assigned each of the students with a partner to help in analysing the requirements. There is no detail explanation on their pair analysis approach. Their pair analysis approach does not emphasize on communication which might lead to silent or sleeping partner in the pair. Responsibilities or roles conflict will be a hindrance among two during requirement analysis due to the difference in personalities and cultures. However, the reported pair analysis was designed in the field of software engineering education to help the students in an academic setting.

In addition, a similar work by Kamalrudin et al. on an approach, Pair-Oriented Requirement Engineering (PORE), adopts Essential Use Case model to gather and analyze multi-lingual requirement [2]. Kamalrudin et al. vision the emergence of globalization in the software industry whereby multiple languages are needed to cater for the project development. Thus, they shed a light on multi-lingual requirements to develop correct and consistent requirements by adopting pair concept into requirement analysis activities. However, PORE approach adopted Essential Use Case model derived from Malay and English language is fully depend on the pattern library and cater for two languages only. Pattern which is not stored or found in the library is considered as beyond the scope of the PORE approach.

Another composition proposed by Yu and Sharp on Analysing Requirements in a Case Study of Pairing is based on experience in pairing development of the OpenOME tool [16]. This paper reports the study of pairing case study on the change logs of the Open OME development and by analysing the aims among stakeholders'' roles diversity. The result of the study showed that the practice of pairing did encourage stakeholders to adopt more roles in return and hence need shorter time to solve their own problems. They have chosen i* language to analyse software requirements even though Organization Modelling Environment, OME, requirements were not analysed thoroughly as the research language is not mature at the early stage of the tool development. Nevertheless, this work is designed for requirement analysis activity in RE cycle by adopting collaborative practice and does not solve the multi-lingual issue derived from globalization.

3.4 Peer

There is an alternative way to analyse requirements, peer review, suggested by Wiegers[17] to improve the quality of requirements. Peer review requires someone other than the author to examine the requirements manually to find defects and at the same time to find improve opportunity. Likewise, Wiegers agreed that review helps to discover more subtle requirements defects as well as to remove requirements errors or defects at the of the requirements stage to save the escalated repairing cost at the later stage. Nevertheless, Peer review is different from the prospective of the process as it only does the inspection on the complete version of the requirements.

In summary, pair, collaboration, group and peer are applied in RE activities due to the concept of "two heads is better than one" where more people can contribute for better quality of requirements.

4.0 Results and Discussions

This section summarizes and synthesizes the findings from our review. The table 1.below illustrates the current state of art of adopting pair, collaboration, group or peer concept into RE process:

Table 1: Pair, collaborative, group and peer work in requirements engineering activities

	Pair	Collaborative	Group	Peer
Requirement Elicitation		[9][10][11]	[13][12]	
Requirement Analysis and Validation	[2][14][15][16]	[7][8]		[17]
Requirement Documentation	-	-	-	-
Requirement Management	-	-	-	-
Total	4	5	2	1

As shown in Table 1, we found that these concepts are mainly applied in requirements elicitation and analysis. Further, more than one approaches are being used in each of the RE activities. For example, collaborative and group works are used in requirements elicitation and pair, collaborative and peer are used in requirements analysis. We also found that there were only twelve related works in Pair that relevant to our domain of content in RE. Specifically, only four works were identified related to pair. The implementation of pair concept has been emphasized more in requirement analysis and validation. The assistance of pair partner aids in checking for requirement error flavors the process of requirement analysis and validation. As the aim of requirements analysis is to find for defect, the only peer work is also implemented here. Further, we found pair is none adopted in other RE activities.

As for the collaborative work, there were a total of five works found being implemented in the RE activities, where three works focuses on requirements elicitation activity and only two works focuses on requirement analysis and validation activity. There were no collaborative concept has been implemented in requirement documentation and requirement management. Besides, two works were identified adopted the group work particularly at the stage of requirements elicitation. However, there were none of work found adopting group concept for the rest of the RE activities. Finally, there was only one work on peer concept which focuses on requirement analysis and validation.

It can be concluded that there was a strong emphasize of work in requirement analysis and validation activity, yet, none work was found on requirement documentation and requirement management activities so far. Although requirement elicitation is a two ways communication intensive activity, there is none pair concept found applied to it. Pair concept should be applied to it for its consistent review and checking during requirements elicitation to reduce the chances of eliciting the inconsistent and incomplete requirements. There were only collaborative and group concept had been adopted in requirement elicitation. Either collaborative or group concept requires more than 2 heads working on the requirement which contribute to more head cost, conflicts, longer time for findings, delay in making conclusion, unnecessary bureaucracy and etc. In fact, work can be less complicated and completed by just two heads assigned to it. The findings from the literature review suggest that the practice of the concept of pair, collaborative, group or peer is not limited in any of the activities of RE.

Table 2: Objectives of related works

Objectives of the related works	
To achieve mutual agreement	[7][8]
To improve communication	[8][10]
To improve requirements selection & prioritization	[8][9]
To reduce ambiguity and inconsistencies	[10][2]
To encourage collaboration	[9][12][11][14][16]
To improve the quality of requirements	[13][15][17]
To improve students' confidence	[15]

The limited literatures were also analyzed based on the objectives of the study. As shown in Table 2, the objectives of the study are identified with seven objectives, i) to achieve mutual agreement, ii) to improve communication, iii) to improve requirements selection and prioritization, iv) to reduce ambiguity and inconsistencies, v) to encourage collaboration, vi) to improve the quality of requirements and lastly vii) to improve students' confidence. These objectives found from the related works were classified according to the similar category of objectives.

We found that most works from the study aims to encourage collaboration between requirements engineers and client-stakeholders. More effective communication and discussion between both parties are required to confirm the quality of the requirements. This is because, the aim of the RE activities is to produce quality requirements that satisfy client-stakeholders' needs. This claim is supported by the evidence shown in Table 2 where three of the works are aiming towards improving the quality of requirements.

5.0 Conclusion

Based on our findings from the analysis of the existing works, there is a limited number of works in pair, collaboration, group or peer concept in the RE activities. It is found that the concept of pair, peer, group and collaborative are mainly applied in requirements elicitation and analysis rather than in requirements documentation and management. Furthermore, the focus of existing works is mostly in achieving collaboration and increasing the quality of requirements. This is due to the concept of "two heads is better than one". It can be implied that effective communication is crucial in determining the quality of requirements.

In addition, we found that pair concept still under explore in the field of RE especially the elicitation although it also helps in improving the communication and the quality of requirements at lower cost and less effort. Therefore, it is planned in our future works, to design a pair approach that can be applied in the elicitation activity aiming at improving the quality of requirements as it is the root that determines the quality of produced requirements.

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Authors' information

Li Lee Ow is currently a master candidate working under the supervision of DrMassilaKamalrudin and DrSafiahSidek at the University of Technical Malaysia Melaka. She received her Bachelor in Computer Science in Software Development from University of Technical Malaysia Melaka. Her research interest lies in the field of software requirement, especially multi-lingual requirements. She can be contacted at lilyow@hotmail.com.

DrMassilaKamalrudin is born in Melaka, Malaysia. She is a Senior Lecturer of Software Engineering department and a research group leader of Innovative Software system & Services group of UTeM. Her first Degree was Computer Science majoring in Software Engineering from Universiti Putra Malaysia in 2003, then completed her MSc in Computing and Software Technology in 2006 from University of Wales, Swansea. In 2011 she gained her PhD from University of Auckland, New Zealand in the area of Requirements Engineering within 3 years and did a post-doctorate study at Swinburne University of Technology, Melbourne Australia. She publishes in numbers of ISI/Scopus journals, IEEE/ACM conference proceedings and book chapters especially in the area of automated software engineering and requirements engineering. Her main interests of research are requirements engineering, security requirements, global software development and software tool and methodology. DrKamalrudin is also a member of IEEE and Malaysia Software Engineering Group (MYSEIG).

SafiahSidek is a senior lecturer at the Centre for Languages and Human Development, UniversitiTeknikal Malaysia Melaka. She currently holds the position of Deputy Dean of Academic at the center. She has a degree in Business Economics from Brock University, Canada and Masters in Science (TESL) from Universiti Putra Malaysia (UPM). She completed her PhD at Deakin University, Australia focusing on the use of online technology and changes in academics' identities. Her research interests include issues in globalisation, innovation and change, the use of online technology and research products commercialisation. She has been actively involved in research related to the use of technology. Besides being a research member for several research projects, she has led several research projects at the university level as well as the national level. At present, she is an active and key member of a research group, named Innovative Software System and Services (IS3). Her significant contribution in this research group is drawn from her expertise in the social aspect of the use of technology. She has been actively involved in several ICT product innovations by investigating users' acceptance and user's behaviour on the newly developed technology, particularly related to the Internet of Things. Among the research projects that she is currently involved are the investigation of a sustainable usage of health information systems in Malaysian hospitals and the investigation of users' behaviour on the use of new application in smart phones. Safiah is also a prolific writer and has written and co-authored several articles in journals indexed ISI/Scopus and proceedings as well as book chapters.