IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received February 16, 2020, accepted March 12, 2020, date of publication March 23, 2020, date of current version April 10, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.2982837

Extended Rationale-Based Model for Tacit Knowledge Elicitation in Requirements Elicitation Context

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ABSTRACT The Requirements elicitation involves knowledge intensive and collaborative activities. Requirements engineering research has proposed a range of knowledge elicitation and requirements gathering techniques, few of which apply specific strategies for eliciting tacit knowledge from stakeholders. The difficulty of taking the deliberate advantage of important tacit knowledge of stakeholders is one of the eminent problems in requirements elicitation. This paper proposes a model to define and elicit the tacit knowledge that has been generated during the requirements elicitation process. The model is based on adopting and extending the rationale model for requirements rationale knowledge elicitation in the requirements elicitation process context. Moreover, this paper presents a representation code to express the tacit knowledge in this context. Finally, to evaluate the feasibility of the model, a survey instrument was applied on domain experts to gather their opinion regarding the ability of the proposed model in facilitating tacit knowledge elicitation. In addition, controlled experiment used to evaluate the proposed model. To explore the model, a post-questionnaire was used to identify participants' feedback. The findings of the evaluation methodologies that were used showed that the proposed model can facilitate tacit knowledge elicitation in the requirements elicitation context. Also, the proposed model has a significant effect on improving the requirements elicitation.

INDEX TERMS Requirements engineering, requirements elicitation process, rationale-based model, tacit knowledge.

I. INTRODUCTION

Requirements Elicitation (RE) is the process of seeking, determining and capturing all relevant knowledge to produce software requirements. The elicitation process is a core activity requirements engineering [1] and has a direct influence on the developed software quality [2]. Moreover, this process depends on deliberation and discussion between stakeholders. During RE, the stakeholders work collaboratively to consume and produce considerable amounts of knowledge to define and discover requirements and make decisions accordingly, as well as establishing their priorities [2], [3]. The stakeholders perform the tasks in RE depending on their backgrounds, perspectives, interests, experiences and expectations or assumptions that are known as their tacit knowledge [4], [5]. The tacit knowledge of RE consists of intuition and inspiration that arises in a stakeholder while exploring solutions to the various problems. The characterization of tacit knowledge relies on an individual's analytical abilities, reflections, experience, and creativity. It is reflected in ideas, solutions, innovation and design [6]. This research has focused on identifying different types of individual tacit knowledge stocks potentially contributing to improve the RE process.

During requirements engineering processes, tacit knowledge lies within the requirements. Unfortunately, tacit knowledge, which is valuable information that supports the software domain and requirements, can remain unclear or hidden [4]. According to Gacitua [7], if the critical expectations, knowledge, and needs of the stakeholders remain in

The associate editor coordinating the review of this manuscript and approving it for publication was Michael Lyu.

their minds, this could lead to serious problems in terms of requirements. It is very important to reach an understanding of requirements by taking into account the different perspectives and interpretations of the stakeholders [8].

RE involves a number of decisions that can be affected by the valuable knowledge the stakeholders have at a certain time [9]. Accordingly, considerable amounts of knowledge in this field arise in the form of rationale behind decisions or domain assumptions [10], [11]. Moreover, the decisions are constructed based on stakeholders' reasoning, justification, opinions, and beliefs, and this is referred to as the rationale [12]. Capturing this rationale would make stakeholders' tacit knowledge about decisions and needs more transparent [12]. This would lead to improving the understanding of the requirements and their reasoning through eliminating the requirements that are ambiguous, incorrect or incomplete. Having a different understanding and perspectives about requirements between the stakeholders occurs as a result of tacit knowledge remaining in stakeholders heads [4].

As part of RE, the stakeholders deliberate, whereupon arguments and conflicts arise naturally to form the requirements rationale [13]. Capturing the rationale behind the requirements is typically not done during RE [14]. Traditionally, the rationale behind the concluded list of requirements is not documented. In order to represent the tacit knowledge in the form of the requirements rationale, there is a need to use appropriate methods to elicit and capture tacit knowledge [15]. Capturing tacit knowledge involves going through different stages that are concerned with identifying the knowledge artifacts and getting more detailed information about these specific artifacts [16].

Requirements rationale knowledge management is beneficial but also costly, and considerable resources, time, and effort are required before benefits [17]. However, in other side capturing tacit knowledge in the form of a requirements rationale is expected to be useful in many cases, such as providing greater help in understanding the complexity of the software application, for maintenance, for future evolution of the software, to assess changes and to predict possible changes [13], [18]–[20].People who involved in maintenance or change requirements activities can use the documentation produced by the rationale model to avoid spending time reconsidering decisions that have been previously considered [21].Furthermore, a rationale can help in reuse when similar issues occur and aids in the next project succeed [17]. Rationale reuse improves, reducing effort and decision time by avoiding several repetitive tasks [20]. Additionally, capturing the rationale prevents valuable tacit knowledge that remains hidden from getting lost when people leave the organization [3]. Indeed, undocumented rationales contribute to defect occurrences [19]. Moreover, this document can also be an aid in building a cumulative base of tacit knowledge, which would be a useful learning tool to both students of design and practicing analyses and developers [22]. If the rationale support tools are integrated into tools already used by the developers, then it might be possible to present the rationale exactly when it is needed without extra effort from the developer [10].

The Rationale Model (RM) is a deliberation representation model that aims to capture the requirements and formulated decisions and their justifications. It consists of the encountered questions or issues, investigating alternatives to solve the issues, the criteria selected to evaluate the alternatives and the debate that led to making the decision [23]. Rationale is also often found in informal artifacts such as team deliberations or sketches. Externalizing tacit knowledge of stakeholders by explaining the different perspectives, would help stakeholders align their decisions that are influenced by tacit knowledge and support the software domain and requirements by capturing stakeholder rationale [4], [12].

Researchers have suggested different RM, such as Issue-Based Information System (IBIS) and Question, Option, and Criteria (QOC). These models enable the representation of rationale knowledge, but are rarely used in practice [3]. IBIS represents rationale as decision-making steps and uses abstractions capturing for issues, options, arguments, and resolutions [24], [25]. Meanwhile, QOC is an extension of IBIS with criteria. It represents rationale as a space of alternatives and evaluation criteria, reconstructing the rationale after decisions are made [26].

The purpose of this paper is to develop a model to elicit tacit knowledge elements in the context of RE process. The presented model adopts and extends the existing RM by adding elements used to express the stakeholder's analytical abilities, reflections, and creativity to represent tacit knowledge. The model called Extended Rationale Based for eliciting Tacit Knowledge (ERBeTK). The goal of the paper is to explore the ability of the model to elicit tacit knowledge. The research questions are as follows RQ1: Can stakeholders' tacit knowledge be represented by RM model in RE? RQ2: What are the tacit knowledge elements that should be elicited in the RE process?

The paper is structured as follows. Section 2 discusses some related works. Section 3 discusses the development of the proposed model. Section 4 describes the research methods used to evaluate the model. Section 5 analysis and reports the results of the model evaluation. Section 6 lists the possible threats to the validity of the work, while. Section 7 provides the conclusions.

II. RELATED WORKS

Defining correct and complete requirements depends on the stakeholders' experiences, background, assumptions, beliefs and perceptions. The inability to elicit tacit knowledge can contribute to both loss of market opportunities and possible systems failure [27]. The importance of tacit knowledge in requirements engineering is widely acknowledged [27]–[29]. However, tacit knowledge appears to be a problem in the RE that is rarely addressed [30]. In recent years, researchers have paid more attention to capturing tacit knowledge during the RE process from different perspectives. Some studies focused on analyzing RE methods used to capture tacit knowledge.

For instance, Friedrich and Van der Poll [31] focused on capturing customer's tacit knowledge. They concluded that some of the RE techniques, such as JAD sessions, RAD elicitations and the use of Use Case model are often unable to elicit tacit domain knowledge effectively. Meanwhile, Goguen and Linde [32] studied tacit knowledge in RE from a social perspective. The study explored the nature of information and requirements, and analyzed some of the RE methods, including introspection, questionnaire and protocol analysis. He mentioned that those elicitation requirements methods had limitations in terms of dealing with tacit knowledge. Therefore, he suggested using various combinations of RE methods. Furthermore, Freeman [33] considered the effectiveness of using a concept maps technique to facilitate tacit knowledge conversion during requirements elicitation. His research was conducted by getting college students to work on short software development projects in small groups. The groups used concept maps to reach a shared understanding of the required software solution. The results of his study indicate that the concept map did not assist the analysts during requirements elicitation. Moreover, Mujeye [34] studied the nature of tacit knowledge by investigating concept map effectiveness in facilitating the knowledge conversion process. His research was conducted by 20 groups of participants that took part in a software requirements elicitation project using concept maps. The study results suggested that concept maps do not have any effect in facilitating tacit knowledge conversion. Additionally, Reichental [35] explored interview techniques. Reichenta's work involved systems analysts utilizing different interview techniques with the aim of finding out the effects of tacit knowledge in relation to requirements elicitation.

The literature also reported a number of systems that have evaluated and reviewed tacit knowledge and its effect on requirements. Some valuable works have developed techniques to expose sources of tacit knowledge during RE and their negative effect on the quality of the requirements. Land *et al.* [36] proposed a formulated conceptual framework that captures both tacit and explicit knowledge in the requirements engineering domain then organizes the knowledge in a useful form. The framework integrates both explicit knowledge in the form of software artifacts and tacit knowledge in the form of arguments that represent the context behind the creation and validation criteria of captured knowledge. However, the work is limited in scope to a model that only captures tacit and explicit knowledge, without considering the techniques and processes. Stone and Sawyer [37] proposed a method to highlight requirements that are potentially based on tacit or tacit-like knowledge. The identification was made possible by examining the origin of each requirement, effectively showing the source material that contributes to it. It was demonstrated that a semantic-level comparison enabling technique was appropriate for this purpose. The research helped to represent the source of requirements based on tacit knowledge that is embedded in the problem domain or the analyst's mind. However, their method does not specifically categorize, or elicit the tacit knowledge of the requirements and its management. From these works, we notice that there is a negative effect on the quality of the requirements because of the presence of unhandled tacit knowledge during requirements elicitation. Moreover, there is a need to develop a model to elicit tacit knowledge. This study used the RM to elicit and represent tacit knowledge during the RE process.

III. EXTENDING THE RM FOR BUILDING ERBeTK MODEL TO ELICIT TACIT KNOWLEDGE

Based on the aspects that concern capturing tacit knowledge, this study proposes a model to collect and elicit tacit knowledge elements. The study used tacit knowledge definitions to find a structured way to represent and express tacit knowledge in the context of RE process. Based on the literature, the study adopted and extended the rationale-based models to organize and represent the tacit knowledge elements.

The valuable source of tacit knowledge is found in the minds of stakeholders. It includes cultural beliefs, values, attitudes, as well as analytical skills, capabilities and expertise. In this model, externalizing this tacit knowledge is conducted through a communication platform such as a face-to-face and virtual knowledge-sharing community between the project stakeholders. Each stakeholder submits an initial statement of need. Each statement of need is discussed and deliberated to externalize the tacit knowledge.

A. THE MODEL

The tacit knowledge was represented as the rationale of that statement of need. Stakeholders' tacit knowledge provides a detailed account of how requirements have been selected and why, based on their experiences, background, skills, beliefs and perceptions. ERBeTK model is based on Question Option Criteria (QOC) rationale model elements to structure the stakeholders' tacit knowledge. The original QOC investigated the available options for a question that was raised and then evaluated and selected an option according to a list of criteria. The ERBeTK model is an extension of QOC that enables the structuring and eliciting of tacit knowledge during the RE process. ERBeTK model consists of the original QOC elements (questions/issue, options, criterions and decision options) as depicted in Figure 1.

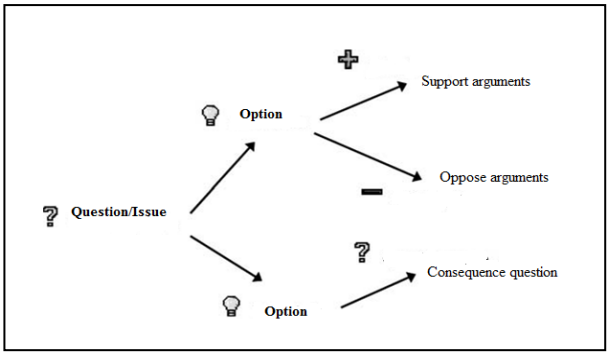

FIGURE 1. QOC elements.

ERBeTK model is started by raising questions to clarify each statement of need regarding (functional or non-functional requirement). Different options that refer to stakeholders' opinion to solve/answer the question/issue are described. Therefore, the stakeholders are assigned options based on their expertise and knowledge of the topic. The alternative options could minimize the ambiguity by providing more understanding and the ability to view more features regarding how the questions/issues could be solved. Each option may link to several questions/issues in order to obtain more detail, and this is called consequence questions. The selection of an option has to be analyzed according to a list of criteria. Criteria representing the qualities are used to evaluate options in a certain context based on the knowledge of the participants. A criterion is also reflected in arguments where it can be supported or opposed. The stakeholders will be able to participate in discussions stating their viewpoints in terms of arguments to support or oppose various solutions. The criterion represents the stakeholders' tacit knowledge of the desirable properties of requirements that must be satisfied. The fully agreed option that is supported by arguments becomes the decision option. The tacit knowledge of the stakeholders requires more elements to be represented. Besides the original QOC elements, this study added three more elements to construct the ERBeTK model, as shown in Figure 2.

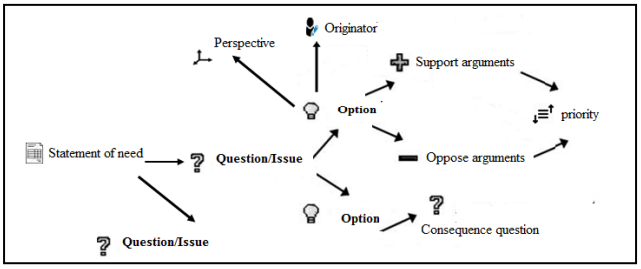

FIGURE 2. ERBeTK elements.

The first element is the knowledge originator which indicates the source the knowledge was gathered from. The quality of this elicited knowledge depends on the cognitive skills, self-knowledge, emotional resilience, and personal drive of the stakeholder bearing the tacit knowledge. Therefore, knowing the originator would indicate how truthful, concise, recent and up-to-date the knowledge is.

The second element, namely perspective represents how the stakeholder thinks about the problem. The stakeholders' perspective presents the behaviorist thought in terms of understanding the problem. Therefore, the stakeholders identify the viewpoint of the option that was used to deduce the solution, such as constraints, mean of documentation, organization policy and role. There is a need for analyzing all the stakeholders' viewpoints and perspective in order to reach to a consensus that addresses the problems related to the presence of tacit knowledge. Expressing the stakeholder knowledge perspective contributes to reducing ambiguity in requirements.

The third element is the priority that provides the level of strength for an option in the range of -1 to 1. An option with a negative level signifies that the opposing arguments outweigh the supporting arguments and options with a positive level signifying that the supporting arguments outweigh the opposing arguments. An option with 0 level signifies indecisiveness where the number of oppose arguments are equal to the number of support arguments. Each option is associated with weights signifying their degree of support or opposition.

An important feature of ERBeTK model is recording the requirements decision process and relating them to desired quality factors. The elements of a ERBeTK model begin by asking a question around an issue to prompt ideas. The arguments are raised to pros and cons against each idea. The statement of need is initially captured as a neutral node followed by its rationale to understand if the requirements are clear, necessary, feasible and conflict-free, as shown in Figure 3. After building the ERBeTK model the study expresses the tacit knowledge (TK) through a representation code, which can be defined thus:

$$\mathrm{TK} = (\mathrm{I}, \mathrm{Q}, \mathrm{O}, \mathrm{C}, \mathrm{S}, \mathrm{P}, \mathrm{Pr}, \mathrm{CQ}, \mathrm{D}) \quad (1)$$

where:

I = initial context.
Q = clarification question.
O = the option to solve the question.
C = the arguments pros and cons.
S = the knowledge source (the originator).
P = priorities the degree of support or opposition.
Pr = perspective of behaviorist thought.
CQ = consequence questions.
D = the fully agreed decision.

At the end of the knowledge elements elicitation process, all tacit knowledge that has been generated during the RE process is elicited and structured.

B. HOW TO USE THE MODEL

On any project, the stakeholders perform RE to create a set of statements of need. Each statement of need goes through a series of discussions and deliberations to obtain a common understanding of the requirements. During these discussions and deliberations, the tacit knowledge of the stakeholder appears. Thus, each discussion and deliberation captures the tacit knowledge of the statement of need to remove ambiguity and gain a clear understanding of that statement of need.

Every statement of need, $\mathrm{I_i}$ as the initial context, containing n steps series of discussions and deliberations n *dis* steps until retching a common and clear understanding, i.e.,

$$\mathrm{I_i} = dis_1 + dis_2 \ldots dis_n$$

Each discussion and deliberation *dis* involves eliciting the tacit knowledge elements for each statement of need, $\mathrm{I_i}$.

$$dis_i(\mathrm{I_i}) = (\mathrm{Q_i}, \mathrm{O_i}, \mathrm{C_i}, \mathrm{S_i}, \mathrm{P_i}, \mathrm{Pr_i}, \mathrm{CQ_i}, \mathrm{D_i}) \rightarrow \mathrm{TK_i}(\mathrm{I_i}) \quad (2)$$

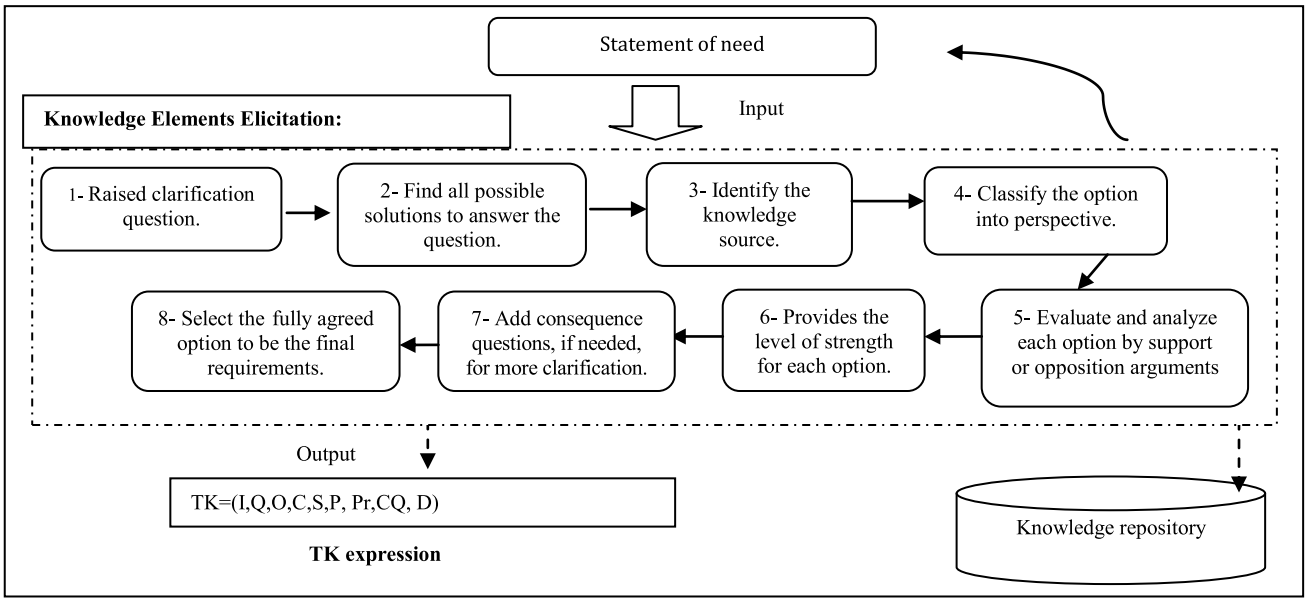

FIGURE 3. The ERBeTK model.

Q_i, O_i, C_i, S_i, P_i, Pr_i, CQ_i, D_i, are the tacit knowledge elements that are elicited during dis_i for the statement of need, I_i. The C_i, S_i, P_i, Pr_i represent theset of elements used to make D_i. All the $dis_i(I_i)$ store in the knowledge repository for future reuse.

IV. THE RESEARCH METHOD

This section presents the methodologies used to evaluate the feasibility of the model. A survey instrument and experimental study were adopted to evaluate the model and test the study hypotheses.

A. MODEL EVALUATION THROUGH A SURVEY ON DOMAIN EXPERTS

The survey instrument was applied on domain experts to gather their feedback regarding the ability of the proposed elements in facilitating tacit knowledge elicitation. The questionnaire was conducted to obtain reliable opinions from a group of experts with a wide range of expertise regarding requirements elicitation. Expert opinions were collected following the experts' review and understanding of the proposed model. Some of experts were individually interviewed for more explanation of the model's processes.

The questionnaire was used to determine the expert's agreement or disagreement regarding using the model's elements to represent the tacit knowledge of stakeholders during the RE process. The data in the questionnaire was coded for analysis by assigning a specific weight for each answer. In this questionnaire the scores were categorized as agree and disagree. The questionnaire consisted of closed questions asking about the usefulness of knowledge gained through the model and open questions related to why the expert saw this as being useful.

The survey was distributed among 20 experts and only 13 responded to the survey. The targeted populations for the survey were academic and practical experts in RE process from different organizational activities, and the data characteristics of the respondents are shown in Table 1.

TABLE 1. The data characteristics of respondents.

Characteristics	Analysis	
Organizational activity	Financial	8%
	Services	15%
	Educational	69%
	Government	8%
Number of years experience in the software engineering	1 – 3 years	8%
	More than 5 years	92%
The job that most closely describes the expert's role when participating in the requirements elicitation process	Business Analyst	15%
	Knowledge Engineer	31%
	Requirements Engineer	23%
	Software Engineer	8%
	Project Manager	23%

The respondents belong to different organizational activities, and the study model was reviewed based on an academic and practical perspective.

About 70% of respondents were from the educational sector. According to experience in requirements engineering (RE), 92% of respondents' have more than 5 years of experience in RE, while 8% of respondents have 1-3 years' experience in RE practice. Most of the respondents are knowledge engineers, requirements engineers or project managers.

B. MODEL EVALUATION THROUGH EXPERIMENTAL STUDY

The other method used to evaluate the model is an experimental study. This model was expected to improve the RE process

by eliciting the tacit knowledge generated during the elicitation session. The experiment's aim is to examine the ERBeTK model in facilitating tacit knowledge elicitation. The independent variable for the experimental study is the study model (ERBeTK). The dependent variable facilitates tacit knowledge elicitation. In this study facilitating tacit knowledge elicitation was measured by the ability of RE techniques to acquire comprehensive knowledge. The domain knowledge items were elicited during the requirements elicitation session were used to determine the comprehensiveness of knowledge. Based on the literature, the problem domain knowledge is composed of different types of items. This study considers the following problem domain items: concepts, processes and requirements, as defined in [38]. The facilitating to elicit tacit knowledge is calculated by the following formula

$$Facilitating = \#\ of\ concepts + \#\ of\ process + \#\ of\ requirements \quad (3)$$

Table 2 shows an example of domain knowledge elements extracted from one of the experiment projects.

TABLE 2. Example of domain knowledge elements of project "Public Reader."

Item Type	Description
Requirements	R1: The user shall be able to limit the retrieved tweets using multiple ways such as verified accounts, generated location, age, date and trending tweets. R2: The system shall be able to accept any type of characters. .....
Concepts	C1: Normalize C2: Tokenization .....
Process	P1: Accept any type of characters P2: Limit the retrieved tweets .....

The main aim of the research is to experimentally analyze the feasibility of the model in term of facilitating tacit knowledge elicitation in requirements elicitation process. The main experimental hypothesis to achieve the proposed objective is as follows:

H0: The extended rationale-based (TK-ERB) model will not facilitate tacit knowledge elicitation process.

H1: The extended rationale-based (TK-ERB) model will facilitate tacit knowledge elicitation process.

The primary evaluation context is graduation projects that provide participants with a realistic requirements engineering experience which participants build in order to demonstrate a system for a real client. The participants in the experimental study were final year students from the College of Computer and Information Sciences from two large universities in the Kingdom of Saudi Arabia with a background in system analysis and software engineering. The experiments were conducted over four months. A total of 17 students agreed to take part in the experiment. The 17 students' were divided into 4-teams to participate in the experiment for four different project domains. 52.94% of the participants had GPA above 4 points. All participants on this study had to be knowledgeable in the software requirements elicitation process where they have taken a Software Engineering course before being involved in theexperiment. Moreover, all participants have prior work experience through their study period inrequirements elicitation process. TABLE 3 Iillustrates the problem domains used in this experiment.

TABLE 3. Problem domains used in the experiment.

Project name	Description
Child Monitoring Application (CM)	The project aims to develop a child monitoring application. The system presents an approach to monitor the children's behavior and performance in kindergarten. In addition, it provides a communication platform between the parent and the kindergarten.
Smart Medication Application (SM)	The project aims to develop a smart medication application. The project provides an automatic alarm ringing system. The application allows the patients to add details of his/her dosage schedules and activate/deactivate an alarm on their dosage timings.
Sentiment Analysis (public reader)	The project aims to develop a web-based application using sentiment analysis. The tool provides a helpful way for beneficiaries to understand public feelings, and opinions such as product reviews, posts, tweets and comments taking place about them, and helps them react and take action accordingly.
Expenses/ Incomes Management Application (SIM)	The project aims to develop an expenses/ incomes management application. The project provides a solution to automatically manage and analyze the user's daily incomes/expenses.

The experiment was conducted over two RE sessions. The first session used one of the traditional RE techniques (structured interview and questionnaire) to elicit the requirements. The second session used the study model to elicit the requirements. The study's perspective mainly compares the quality of the requirement lists (RL) that are elicited in the two RE sessions. The quality focuses on evaluating the RLs in terms of counting the detailed descriptions of the domain knowledge. The RLs were evaluated by external experts to remove the incorrect requirements before extracting the detailed descriptions of the domain knowledge for more accurate comparison. The experimental procedure is shown in Figure 4.

In order to compare the techniques used in RE process in terms of facilitating the elicitation of tacit knowledge manual analysis was used to review the projects' RLs. The feasibility of the model was measured by plotting the number of domain knowledge elements found in RLs. Moreover, the feasibility of the model was determined by comparing the total number of domain knowledge elements with and without using the study model. If the number of requirements, concepts and

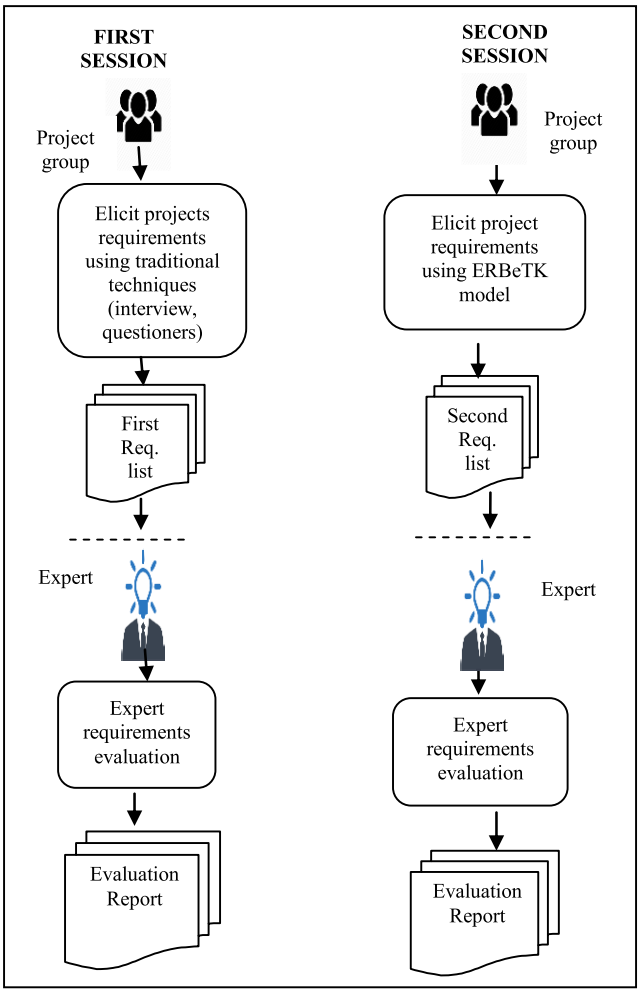

FIGURE 4. Experimental procedure.

processes is increased in the RLs generated by the study model, this would mean that the proposed model has satisfactory results and works effectively in facilitating the tacit knowledge elements.

At the end of the experiment, the participants were interviewed individually and completed a post-experimental questionnaire in order to collect information regarding their feedback on the feasibility of the model in facilitating the elicitation of tacit knowledge. In this questionnaire, a Likert five-item scale was used. The weight distribution was used to distinguish positive and negative perceptions. The Cronbac's α was used to test the reliability (Cronbac's α was 0.91).

V. RESULTS ANALYSIS AND INTERPRETATION

This section analyzes and reports the results of the model evaluation. The purpose of the research was to test the hypothesis (H0,H1) that stated the use of extended rationale based model during RE process would facilitate the elicitation of the tacit knowledge that could affect the quality of the requirements. The indication of whether to accept this hypothesis or reject it was based on two aspects: analyzing experts' opinions and the experimental study results.

A. SURVEY ON DOMAIN EXPERTS RESULT ANALYSIS

In this section, the results of the questionnaire survey method are presented. The results of the questionnaire were compared to explore the extent to which the models' elements represent the stakeholder's tacit knowledge. The statements in the questionnaire are described in TABLE 4.

TABLE 4. Domain experts survey statements with their code#.

Statements	Code #
• Knowledge gained through the proposed model will help in justifying the necessity of the requirements.	Q1
• Knowledge gained through the proposed model will help provide the ability to satisfy and make the constraints achievable.	Q2
• Knowledge gained through the proposed model will help explain the requirements through the additional information supplied (e.g. inquiries, alternative solutions, evaluation criteria and supporting or opposing arguments).	Q3
• Classifying the knowledge into various perspectives (such as tasks, type of documentation, organization policy, role) will help elicit accurate knowledge.	Q4
• Associating the knowledge with the person responsible for defining it (the originator) will help increase its strength, the ability to adopt it and the ability to adopt and reuse it.	Q5
• Assigning priority level to the knowledge will increase its strength and ability to adopt and reuse it.	Q6
• Representing and documenting the tacit knowledge in the form of rationale elements (questions/issues, options, criterions and decision options) will be useful for future knowledge reuse.	Q7
• Exploiting these elements (questions/issues, options, criterions, decision, options, originator, the classification and the priority level) will be suitable to represent the required tacit knowledge element that should be elicited.	Q8
• Utilizing alternatives of requirements will be suitable to reflect the knowledge experience.	Q9

The percentage analysis of the respondents' opinions about each statement is shown in Figure 5.

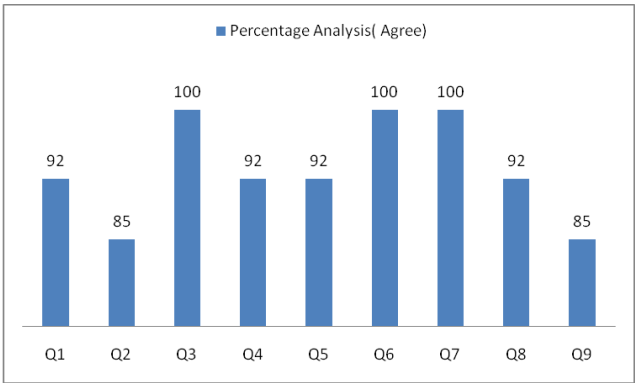

FIGURE 5. The percentage analysis.

According to the results in Figure 5, that most of the experts' opinions are positive. They think that the model is useful in eliciting tacit knowledge. Furthermore, they believe that it has a significant positive impact on improving the RE process. Figure 5 indicates that most of the experts agree that the rationale model and the extended elements are suitable to represent the required tacit knowledge element that should be elicited at 100% and 92% respectively. About 92% agree that classifying the knowledge into various perspectives that presents the behaviorist thoughts of stakeholders helped to elicit accurate knowledge. Respondents also added that ''indeed categorizing the knowledge will consequently elicit the needs accurately'' whilst others claimed that, ''Classifying leads to better understanding and analysis''. Regarding Q5,''associating the knowledge with the person responsible for defining it (the originator) will help increase its strength, the ability to adopt it and the ability to adopt and reuse it'' about 92% agree with this statement and they mentioned that knowing the source of the knowledge is '' a motivating factor to verify the originality of acquired knowledge''. All of the experts agree that ''assigning priority level to the knowledge increased its strength and ability to adopt and reuse it''. Regarding assigning priority of the elicited knowledge, the experts mentioned it ''helps to know the risks of adopting and reuse it''.

B. EXPERIMENTAL STUDY RESULT ANALYSIS

The experimental study results were analyzed in two steps. First, analyze the RLs that have been generated from the two sessions of experiment. Second, at the end of sessions, a post-experimental questionnaire was filled by each participant to investigate participants' feedback on the feasibility of representing tacit knowledge elements through the ERBeTK elements.

The RLs were analyzed by domain expert to remove the incorrect requirements from the RLs before determine the domain knowledge items. Then the facilitating formula was used to compare between the techniques used in each RE session in term of feasibility of eliciting tacit knowledge elements. The domain knowledge items for each project problem are shown in TABLE 5.

The findings presented in TABLE 5 show that the knowledge items (requirements, concepts and processes) that have been elicited for each project are increased after using the ERBeTK. Using ERBeTK model during the RE session facilitates the elicitation of tacit knowledge by extracting more domain knowledge elements where the elements are increased in the four projects as 32%, 34%,17% and 32% respectively. Therefore, the result of this analysis showed a significant difference in the knowledge items between the techniques used in the two sessions. As such, ERBeTK model has the ability to acquire more comprehensive knowledge than the other traditional elicitation technique.

At the end of the experiment, a post-experimental questionnaire was completed by each participant. The questionnaire was analyzed by using the correlation coefficient in quantitative analysis to analyze the participants' perceptions and attitudes regarding the use of the ERBeTK. This type of analysis was used to evaluate the ERBeTK model in facilitating the elicitation of tacit knowledge elements in the context of requirements elicitation process. The ERBeTK model facilitates the tacit knowledge elicitation through reflecting tacit knowledge features into the TK-ERB model elements. The T-test was performed to explore the relationship between ERBeTK model and the feasibility of representing tacit knowledge elements according to participants' responses. The evaluation aspects regarding the knowledge gained through using the ERBeTK model that ware used in the T-test are described in TABLE 6. The aim was to determine if evaluation aspects have significant influence or relationship with the representing tacit knowledge. The results of T-test are shown in shown in TABLE 7.

TABLE 5. Items that define the domain knowledge.

Tacit knowledge elicitation technique	Proj.	Items that define the domain knowledge			Facilitating =#of concepts +#of process+ #of req.
		Concept	Process	Req.	
Traditional elicitation technique	CMP	19	13	11	43
	SMP	11	12	9	32
	Public reader	18	15	17	50
	SIMP	11	9	10	30
ERBeTK	CMP	32	21	22	75
	SMP	21	25	20	66
	Public reader	22	24	21	67
	SIMP	24	19	19	62

TABLE 6. Statement for representing tacit knowledge using ERBeTK.

Evaluation aspect
• Complement the understanding of the requirements.
• Justifying the necessity of the requirements.
• Provide the ability to satisfy and make the constraints achievable.
• Explain the requirements through the additional information supplied (e.g. inquiries, alternative solutions, evaluation criteria and supporting or opposing arguments).
• Elicit accurate knowledge by classifying the knowledge into various perspectives (such as tasks, type of documentation, organization policy, role).
• Increase the strength, ability to adopt and reuse of the knowledge by associating it with the person responsible for defining it (the originator).
• Assigning priority level to the gained knowledge increased its strength and ability to adopt and reuse it.
• Representing and documenting the tacit knowledge in the form of rationale elements (questions/issues, options, criterions and decision options) was useful for future knowledge reuse.
• Exploiting these elements (questions/issues, options, criterions, decision, options, originator, the classification and the priority level) was suitable to represent the required tacit knowledge element that should be elicited.
• Utilizing alternatives of requirements will be suitable to reflect the knowledge experience.

TABLE 7. General T test results for representing tacit knowledge using ERBeTK.

	Feasibility of representing tacit knowledge elements		
Extended rationale model	**t-value**	**DF**	**P-value**
	2.11	16	0.00**

Notes: *,**,***Correlation is significant at the 0.05 ,0.01 and 0.001levels,

According to Table 7 there is a strong, significant and positive relationship between the ERBeTK model and the tacit knowledge elicitation. Therefore, this result supports the H1 hypothesis and H0 was rejected at a level of confidence of 95%. All the students during the experiment session they mentioned that ''this way of eliciting requirements made us think about things we did not think of before''.

VI. THREAT TO VALIDITY

This section discusses issues with the potential to threaten the validity of the experiment [39]. The following are the factors that affect the validity of our study:

1) INTERNAL VALIDITY: In the experiment, the subjects were affected negatively during the second session that may cause threats to the outcome of that session.
2) CONSTRUCT VALIDITY: In the experiment, two different elicitation techniques were applied on two different session; the results of the second session may be affected by the subjects' previous knowledge.
3) CONCLUSION THREAT: In the experiment, the correlation coefficient was used to investigate the relationship between the variables in the hypothesis. Moreover, to enhance the reliability of the measuring instrument, a pilot study was conducted initially, which improved the experiment.
4) EXTERNAL THREAT: In the experiment, subjects come from a convenience rather than a random sample. The subjects have been selected based on the ability to build domain ontology for their projects.

VII. CONCLUSION

In requirements engineering, the explanation of opinion, practices, beliefs, or an underlying reason is important to capture, document and reuse this knowledge in software organizations. However, capturing how certain requirements decisions were taken usually means articulating tacit knowledge. Eliciting tacit knowledge retains that knowledge in order to avoid making the same mistakes repeatedly or to avoid knowledge being lost when people leave the organization.

Working with requirements, it is essential to have diverse knowledge to refine or understand the requirements decision. In this context, handling the diversity of domain knowledge for obtaining shared understanding of the problem the stakeholders surface the tacit assumptions and ask revealing questions that can lead to exposing issues that domain experts have ignored.

This paper proposes an extended version of the QOC deliberations representation model which is used to capture details of any collaborative decision-making process. The extended version of QOC is designed in such a way as to elicit and represent the tacit knowledge. The aim of this paper was to develop a model to elicit and represent tacit knowledge in order to improve the RE process. The results of the domain expert questionnaire and experimental study showed the model is able to elicit and represent the stakeholders' tacit knowledge. The results of the experimental study show that the proposed model is more reliable and powerful than traditional RE techniques in capturing stakeholders' tacit knowledge.

The ERBeTK model provides many advantages: it gains a deeper understanding and eliciting more details about the problem domain that in turn helps to obtain requirements that meet the stakeholders' needs, reduces the consumed time to address any misunderstanding or ambiguity in RL and enhances on decision support by tracing each requirements and to recognize the underlying logic behind it.

According to the stages of capturing tacit knowledge, this research was concerned with two aspects: (i) Identifying and collecting the knowledge area and (ii) Obtaining more detailed knowledge about specific artifacts. This paper worked on proposing and developing a model to elicit tacit knowledge to obtain detailed knowledge elements. As future work, there is a need to integrate the proposed model with other technology to identify and collect the knowledge area (that represents the knowledge artifacts).

ACKNOWLEDGMENT

The authors would like to thank Al Imam Mohammad Ibn Saud Islamic University (IMSIU) and Deanship of Scientific Research at King Saud University for funding and supporting this research through the initiative of DSR Graduate Students Research Support (GSR).

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