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QUALITATIVE COMPARISONS OF ELICITATION TECHNIQUES IN REQUIREMENT ENGINEERING

Olatunji J. Okesola[1], Kennedy Okokpujie[2], Rowland Goddy-Worlu[3], Afolakemi Ogunbanwo[4] and Olamma Iheanetu[3]
[1]Department of Computational Sciences, First Technical University, Ibadan, Nigeria
[2]Department of Electrical and Information Engineering, Covenant University, Ota, Nigeria
[3]Department of Computer and Information Sciences, Covenant University, Ota, Nigeria
[4]Department of Computer Sciences, Tai Solarin University of Education, Ijebu-Ode, Nigeria
E-Mail: kennedy.okokpujie@covenantuniversity.edu.ng

ABSTRACT

It is often emphasized that the quality of elicited requirement is mostly influenced by the elicitation techniques employed to gather software requirements. Many elicitation techniques have been presented in requirement engineering but they are hardly adopted in practice as the available empirical and comparative evaluations are inadequate to guide the software industry on which technique is better. Classifying a selection of seven requirement elicitation techniques as collaborative, individual or contextual, this study compares the popular techniques using two groups of qualitative criteria - terms of information collection and quality of feedback information. The evaluation results are tabulated and the findings are depicted by spider diagrams. The study concludes that each technique has its strengths and weaknesses, the factors software engineers should weigh when selecting appropriate techniques for requirement elicitation.

Keywords: elicitation techniques; qualitative comparison, requirement engineering, software engineering, spider diagram.

INTRODUCTION

The Requirement Engineering (RE) process comes at early phase of software development and remains the most important phase of the software development life cycle (SDLC). This is because, it is the only phase amongst several activities where the imprecise, incomplete needs and wants of the potential users of software is translated into complete, precise and formal specifications [1]. A most critical activity is requirement elicitation [2] and it is fundamental to SDLC [3] as its methods determines the worth of requirements to be obtained. Since the quality of the system to be implemented is dependent on the quality of requirements elicited which is also a function of the elicitation techniques used, adequate comparisons of these techniques is a must to guide the requirement engineers in the choice of the right techniques for requirement elicitation.

Requirements are particulars of the functionalities that the system ought to provide, the imperatives on the system and the foundation information that is important to deployment of the system [4]. Hence, many techniques were developed even from other sciences to capture required information for system development [5]. However, due to their intrinsic nature and the diversity of their sources, their performances are different [6] and thereby calling for empirical means of measurement.

Several works [7], [8] [9] have been done on the effectiveness of the requirement elicitation techniques and why some techniques [10],[11] are more preferable. There are also quite a number of studies on the quantitative comparison of these techniques [12] but only very few works are available on the qualitative assessment thereby posing a major concern to the requirement engineers on the best techniques to employ.

Aiming at identifying the most appropriate elicitation techniques, this work carried out a qualitative comparative analysis of selected techniques hanging on classification proposed by Yousuf & Asger, [13] and [14]. A set of metric obtained from Wellsandt *et al.*, [12] is considered to represent the construct and evaluate the techniques. The results are tabulated and illustrated.

RELATED WORKS

Wellsandt *et al.*, [12] made a comparison of eight selected elicitation techniques which were evaluated by six qualitative criteria with emphasis on data collection terms and information qualities. They presented the qualitative results in net-diagrams, availing the techniques to further arguments especially where individual user's requirement are to be elicited.

Ikram, Siddiqui, & Khan, [15] performed a controlled experiment where two security elicitation techniques - Misuse cases (MUC) and Issue based information systems (IBIS) - were compared. With a 2*2 factorial design, 30 undergraduate students were randomly selected and made to individually solve the security goal identification tasks using the two techniques. Although, limited to undergraduates' participation, the study established that results interpretation is slower in IBIS where there is low-level of details while it is faster and much effective in MUC for security goals.

Using repertory grid technique, Moreno, [16] attempted to identify the vision of requirement engineering novice and related same to that of the experts on the effectiveness of requirements elicitation techniques. His result suggested that novice engineers need more extensive training and exposures to be able to recognize the material differences in the impacts of elicitation techniques and make use of the most appropriate techniques for requirements elicitation.

In his own study, Hudlicka, [17] gave a case study where the effectiveness of the three major elicitation

techniques (repertory grid analysis, hierarchical clustering, and multi-dimensional scaling) are commonly used whenever experts are unable to articulate their knowledge to address direct questions. The study compared the techniques on the basis of the number of elicited attributes, the ease of data collection, and the extent to which post-analysis and interpretation is required. Using airline safety inspections domain towards defining inspection indicators, the study results shows that "the repertory grid analysis method generates all of the attributes produced by the other two methods, that it is easy to apply in the field, and is useful without complex analysis and re-interpretation of the results".

Meanwhile, researchers often advise that the most appropriate elicitation technique should be selected for software requirements gathering [18]. Hence, Carrizo, Ortiz, & Aguirre, [19] compared the techniques using systematic mapping to identify the concept of their appropriateness. Following this, Carrizo, [6] presented a systematic mapping of good techniques and compared with the experts opinions towards determining what the software engineers' claim as adequate for requirement elicitation. The result shows a great divergence between the practitioners' and researchers views on the quality of software requirement elicitation techniques. The work therefore calls for more empirical studies to identify a common measure for the effectiveness of gathering techniques.

METHODOLOGY

This research methodology aims at classifying selected techniques as reviewed by Yousuf & Asger, [13] and Zhang, [14]. The elicitation techniques are selected in no particular order but based on their share characteristics, the qualitative criteria of *Wellsandt et al.,* [12]will be employed to evaluate their quality.

The classification of techniques

Characteristics of techniques must be identified and its features considered in order to determine its appropriation for a system development. Hence, this section distinguishes and classifies our elicitation techniques into collaborative, observational, and contextual.

- Collaborative techniques: Collaborative elicitation techniques involve teams or groups of stakeholders who applying their individual expertise on a particular issue agree upon a set of decisions. It involves people from different fields given equal powers to give their opinions regarding a particular system. These techniques include Brainstorming, Workshops. Group work and Joint Application Development [20].
- Observational techniques: This tends to provide a means for individuals to develop substantial understanding and knowledge about an application domain [14]. Individual techniques involve a single individual applying sole expertise in order to elicit requirement. An individual uses his own knowledge or visit the environment in order to study or gain insight [13]. With this to happen most time the individual most be very familiar with the current domain he is working with or must have done a work recently which is similar to that domain.
- Contextual techniques: Contextual elicitation techniques are techniques that collect requirements in context of the user and therefore collect requirements at the workplace of the end user. Requirements are gathered at the working environment where the system will later be used. Examples of the techniques are user scenarios and prototyping [8].

Selected elicitation techniques

The elicitation techniques selected for this study are as discussed below:

- **Brainstorming:** This is a techniques where stakeholders from various fields come together to produce a new idea. Hence, it is classified as a collaborative and fast technique where new requirement are easily generated. It is an informal discussion in which quality opinions are freely accepted and determined by the number of ideas and contributions brought forward [21]. It enables a group of people to take advantage of conventional an logical thinking, as well as embracing spontaneity [22].
- **Workshops:** At a workshop, project's stakeholders come together for a deliberation to gather the requirements for a system under development. This is mostly organized when large requirements are to be elicited [3], and the participation is limited to the stakeholders that are directly affected by the system. Workshop is also a collaborative technique and better used for collecting multiple viewpoints.
- **Prototyping:** A proposed system model or prototype is developed with an initial set of requirements when the stakeholders have little or no idea of the final system's requirements [23]. Series of review and several iterations are made until the stakeholders' satisfaction is met. The prototype depends on the context of the development [13], making the techniques contextual.
- **Joint application development (JAD):** This is a requirement elicitation technique where groups of customers and management work together towards building a project. A highly structured interview is employed over a period of three to six months. It is a collaborative technique as various participants from same or different domains are directly involved.
- **Group work:** In this technique, meetings between the stakeholders and the analyst are fixed after which requirements are communicated and evaluated. Group work is a collaborative technique where a moderator is usually nominated to ensure stakeholders participate actively in the meeting [24].
- **Ethnography:** Ethnography is an observational technique [14] where an analyst studies a culture or an environment in order to deduce requirement. A single requirement engineer may participate in a given environment in order to understand given cultural activities and way of life of its environment. It is a natural requirement classification and thus considered

as an individual centered technique that can easily be integrated with other elicitation technique [13].

- **Introspection:** This is a popular technique and requires the individual analysts to visualize the system's requirements in his own thought. It is best used when the analyst is very familiar with the domain of the system to be developed [25][9]. The technique involves just a single person aiming at generating a set of requirement from his own thought and experience from the use of that particular domain thus this makes it an Individual centered technique.
- **User scenarios:** This is a technique that gives a narrative description of user processes including actions and interactions between them and the system. Scenarios ordinarily does not consider the internal structure of the system but requires an incremental and interactive approach to their development [25]. User scenarios techniques are considered contextual as it explains the theories and context behind why a particular system function is needed by a specific user or group of users.

Table-1. Classification of selected requirement elicitation technique.

S. No	Requirement elicitation technique	Classification
I	Brainstorming	Collaborative Technique
II	Workshop	Collaborative Technique
III	Prototyping	Contextual Technique
IV	Joint Application Development (JAD)	Collaborative Technique
V	Group Work	Collaborative Technique
VI	Ethnography	Observational Technique
VII	Introspection	Observational Technique
VIII	User Scenarios	Contextual Technique

Evaluation criteria

The evaluation criteria as postulated by Wellsandt *et al*., [12] is employed. The criteria are into two groups - Terms of information collection, and Quality of feedback information.

Terms of information collection

These terms are described by timely proximity to use, efforts required per user, needed skills to use the technique.

- **Proximity to use (PTU):** This criteria defines the time interval between the application and actual use of the technique. For instance, observation techniques are applied when the product is in use, while complaints and inquiries techniques are used after. The higher the time interval, the lower the PTU of the technique.
- **Effort per user (EPU):** refers to cost (time, personnel or support, etc.) required to implement an elicitation technique in relation to the number of targeted users.
- **Required skills (SKI):** is the minimum proficiency level required of an operator to effectively use the elicitation technique

Quality of feedback information

This is described by the structure, richness and quantifiability of a typical technique.

- **Structure (STR)** of information induces potential irregularities and ambiguities of information misconception. Structured information such as databases ordinarily has a predefined data model. Natural language and plain text are typical example of unstructured information.
- **Richness (RIC)** refers to the quality of the information obtained (which is required for an improved system or product) from the use of an elicitation technique.
- **Quantifiability (QUA)** defines information obtained from the technique as measurable or not. This criteria is easier to process as it can hardly be misinterpreted.

Results and analysis

The qualitative evaluation results of the elicitation techniques are summarized in Table-2 and discussed thereafter.

PTU: It takes a longer time for all the participants of the system to come together in Brainstorming, Workshop and JAD. This means that the techniques have a larger time interval hence, their PTU is low. For the Group work and Prototyping, the time taken to gather together for requirement elicitation activities is moderate as not many people are involved comparatively. However, PTU is high in Ethnography and Introspection since only one participant each is required, and therefore commences almost immediately without waiting for any other participant.

Table-2. Qualitative evaluation of elicitation techniques.

Criteria	Requirement elicitation technique							
	Brainstorming	**Workshop**	**Prototyping**	**JAD**	**Group work**	**Ethnography**	**Introspection**	**User scenarios**
PTU	Low	Low	Medium	Low	Medium	High	High	High
EPU	Medium	High	High	High	Low	Low	Low	Medium
SKI	Medium	Medium	High	High	Medium	Low	High	Low
QUA	Medium	Medium	High	High	Medium	Medium	Medium	Medium
STR	High	High	Medium	Medium	High	Low	low	High
RIC	High	Medium	High	High	Medium	Medium	Low	Medium
TOTAL	2Hs; 3Ms; 1L	2Hs; 3Ms; 1L	4Hs; 2Ms	4Hs; 1M; 1L	1H; 4Ms; 1L	1H; 2Ms; 3Ls	2Hs; 1M; 3Ls	2Hs; 3Ms; 1L

Effort per user (EPU): The EPU on Prototyping, JAD and Workshop is high as the techniques are expensive in cost and time to organize and use. A typical JAD takes a minimum of three months and involves participants from various independent domains. In Prototyping, stakeholders have little or no idea of the final system requirements [23]; series of system iterations are therefore required to meet their needs. Meanwhile, EPU is low on group work, ethnography and introspection require little efforts to organize and less costly in time, setup and technology usage. However, EPU in Brainstorming and User scenario is at medium because stakeholders from various field are involved in Brainstorming leading to argument which may make it difficult to reach consensus. Similarly, requirement changes is very common in User scenario [25] as theories and context are offered to justify the need of a particular system function.

Required skill (SKI): High skill is required in Introspection for participants to visualize requirement just like in Prototyping where prototypes are involved at different level. JAD technique also calls for high skill due to the technicality in the development process. While moderate skills are expected of participants to give meaningful contributions at the Brainstorming, workshop and group work sessions, very little skill is needed for a user to participate in Ethnography and User scenario techniques.

Quantifiability (QUA): with exceptions to Prototyping and JAD, data collected from other selected requirement techniques here are *mostly* measurable and specifiable. Their result may not necessarily be a system but their outputs can be measured either quantitatively or qualitatively. Therefore quantifiability is adjudged to be medium. However, QUA is high in both prototyping and JAD as a system emerges from either techniques and the progress at each stage can be determined to easily quantify the output.

Structure (STR): The techniques such as brainstorming, workshops, group work and user scenarios already have a predefined template. The membership, size and quality of the participants are clearly specified. Date, time and venue are preplanned and agreed upon. Hence, they have a high structure to elicit requirements. STR of Prototyping is at Medium because the techniques do not have a complete template but follows a routine procedure. Ethnography and Introspection have minimum or no template as requirement are elicited at different instances leaving their structure low.

Richness (RIC): Superior arguments and a number of quality ideas are considered in Brainstorming to guide decision taken. Iteration processes are repeated in Prototyping to improve on the system under development, and a highly structured interview is conducted by group of customers and management to ensure quality in *JAD*. The quality and richness of information obtained from these three techniques is therefore expected to be high as a number of experts are involved with varying ideas and background. However, medium quality is obtained from *Workshop* and *Group work* as not every member of the group may have the required expertise. Ethnography and User scenario techniques will produce an average (medium) quality since the former is a one-man show while the latter is purely narrative, making them subjective. Similarly, Introspection will give low quality as the technique usually involves just an individual who singlehandedly visualizes the system requirement based on his views and experience.

Since it is often difficult to appreciate evaluation results from tables, quality ratings presented on Table 2 are valued as low, medium or high, and used to create the three spider chats in Figure 1a, 1b and 1c which represent observational, collaborative and contextual techniques respectively.

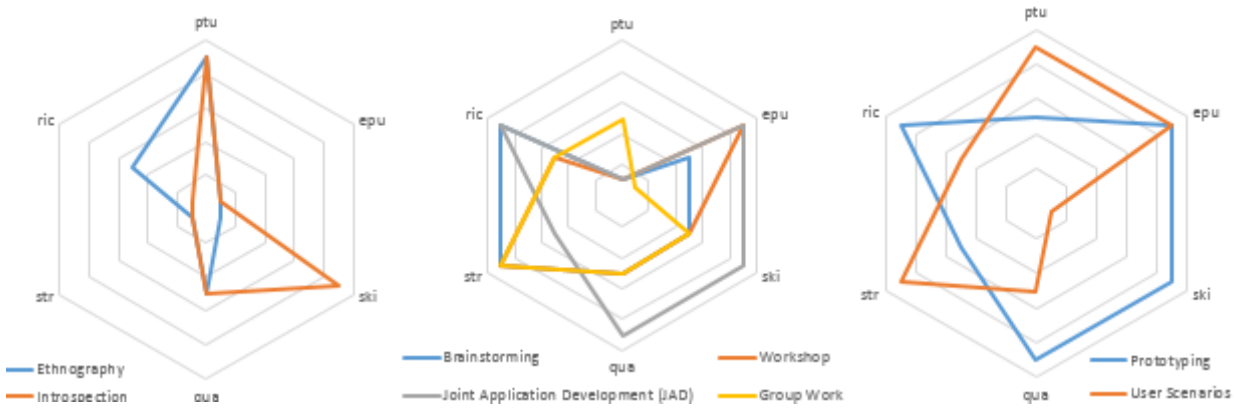

Figure1a-c. Spider chart showing qualitative comparison of Individual centered elicitation techniques.

CONCLUSIONS

None of the selected eight elicitation techniques is entirely weak or strong on all the evaluation criteria. The total performance as summarized on the last row of table 2 confirms that each of the techniques has a Low, Medium and High scores in one or more criteria. Hence we conclude that every technique has its strengths and weaknesses which must be strongly considered when selecting a suitable elicitation technique.

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