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NEW FACTORS THAT AFFECT THE ACTIVITIES OF THE REQUIREMENTS ELICITATION PROCESS

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Abstract

Given that requirements elicitation is one of the important stages in software development, many researchers agree that incorrect, incomplete and confusing requirements have a great negative impact on the quality, cost and delivery time of software projects. Therefore, factors that affect requirements elicitation and the activities of its process have been identified. However, there are no studies on what factors affect the activities Integration, Documentation and Refinement. Moreover, the theories of organizational behaviour, organizational learning, Technology acceptance model, among others, provide factors not studied in the area of requirements elicitation. The purpose of this research is to identify new factors that influence each activity of the requirements elicitation process and, consequently, the quality. Hence, in the present paper seven new factors that affect the activities of the requirements elicitation process are presented: learning capacity, negotiation capacity, permanent staff, perceived utility, confidence, stress, and semi-autonomous. In addition, 17 relationships (factor-activity) have been introduced. An empirical study was carried out on 182 respondents, obtaining, from the analysis of simple and multiple correspondences, that all the proposed factors have an influence between "High" and "Very high". Furthermore, the hypothesis test T-Students, with 95% confidence, verifies that 15 of the 17 relationships are valid.

Keywords: Activities, Factors, Requirements elicitation, Requirements engineering.

1. Introduction

Requirements engineering (RE) is an important and remarkable stage in the life cycle of software development. Many researchers agree that most of the obstacles encountered during software development are largely attributed to engineering requirements [1]. The broad spectrum of tasks and techniques that are carried out to understand the requirements is known as RE [2]. As the years have gone by, different RE models have emerged in order to establish a framework for developing tasks, such as the Wiegers and Beatty models [3], Pohl [4] and Sommerville [1]; all of them consider the requirements elicitation stage.

The requirements elicitation is the ability to work in collaboration with stakeholders so as to discover current product needs and to reach an agreement on the vision and goals of the proposed project. It is considered one of the important stages in software development [5]. Several researchers agree that incorrect, incomplete and confusing requirements have a great negative impact on the quality, cost and delivery time of software projects [1, 6, 7]. In order to overcome these difficulties and to discover the proper needs of stakeholders, in the literature, various processes for requirements elicitation have been proposed [4, 8-10].

However, according to the Chaos Manifesto [11], in 2013 only 39% of the projects are successful, 43% end up with problems and 18% of the projects are unsuccessful; in addition, this report defines a list of factors that cause the failures of the projects and that in some cases cause the project to be cancelled; thus, the "incomplete requirements" is the most critical factor, and the "clear statement of requirements" is one of the three main reasons for the success of a project. The Chaos Report [12] also explains that in 2015 the problems continue, since only 29% of the projects are successful, 52% end up with problems and 19% of the projects are unsuccessful.

On the other hand, the quality of requirements elicitation depends on the activities of the elicitation process, which in turn is affected by personal factors [13-17], and of a technical nature [13-15]. Some studies show Factor-Activity influence relationships [13-17], but there are no studies related to the activities find sources and refine technique, which is also relevant for elicitation. Likewise, the organizational learning theory allows to identify the Learning capacity factor, widely studied in other problems, which could affect the Find sources activity, because the analyst must have the ability to learn how to identify the adequate sources, such as software, users, documents related to the project and other people's experiences. Hence, the purpose of this paper is to identify new factors that influence the activities of the requirements elicitation process, which in turn are based on theories. The proposed model considers seven new factors related to all the activities of the elicitation process.

The rest of the paper is organized as follows. In section 2, the background and motivation of the study are presented. In section 3, 7 factors and 17 hypotheses are presented. To validate the factors and hypotheses, in section 4, the research methodology used is presented. The results and discussion are presented in section 5. Finally, the conclusions are presented in section 6.

2. Background and Motivation

2.1. Activities of the requirements elicitation process

The activities of the requirements elicitation process are part of the different RE models that have emerged in recent years, such as the Wiegers and Beatty models [3], Pohl [4], Sommerville [1], among others. Moreover, as the years have passed, several definitions of requirements elicitation have emerged. According to Bohem [18], elicitation is the first and most critical step within the RE, so, the fact of doing it wrong will lead to products with poor quality, late delivery dates and costs outside of the budget. Loucopoulos and Karakostas [9] defines elicitation as the process of acquiring all the relevant knowledge to produce a model of requirements of a problem and of a certain domain. According to Borland [5], elicitation is the ability to work in collaboration with stakeholders to discover current product needs and to reach an agreement on the vision and goals of the proposed project.

Based on the definitions of requirements elicitation, each author has defined the activities of the elicitation process. Loucopoulos and Karakostas [9] defines 3 activities: i) Knowledge acquisition, ii) Sources determination and iii) Techniques identification. The software engineering body of knowledge (SWEBOK) [10], defines two activities: i) Requirements sources and ii) Elicitation techniques. Mulla and Girase [8] defines 5 activities: i) Identify sources of requirements, ii) Collect the wish list for each corresponding part, iii) Document and refine the wish list, iv) Integrate the wish lists with the various stakeholders and v) Determine the non-functional requirements. Pohl [4] defines three activities: i) Determine the relevant requirements sources, ii) Identify requirements of the sources and iii) Develop new requirements. In the previous research [19], a framework for the literature review was proposed based on the activities of the requirements elicitation process of Pohl [4], Loucopoulos and Karakostas [9] and Mulla and Girase [8], where the following activities were considered: i) Knowledge acquisition, ii) Sources determination, iii) Define technique, vi) Identify requirements, v) Document and vi) Refine. Also, more researches about the activity of "identify requirements" were found.

2.2. Factors

Given that there are problems in requirements elicitation, different works have emerged that identify the factors that influence this task. These works have identified the following factors: i) Factors that influence the whole process of requirements elicitation (Table 1) and ii) Factors that influence a particular activity of the elicitation process (Table 2). As shown in Table 1, there are more works that have studied the factors "rules" and "culture", and it is observed that these factors are oriented to human behaviour.It should be noted that the business management factors [20] refer to the factors related to the business processes, organizational structure and budget of the project.In Table 2, it is observed that the activity Identify wish list is the most studied because most of the studies focus more on the main activity of the elicitation process, without considering all the activities as a whole. It is also observed that only 4 out of 7 activities of the elicitation process have been analysed, but the activities not analysed are also important. For example, "integration" allows negotiating, group and ordering the different requirements captured by the stakeholder.

Table 1. Factors that influence the whole process of requirements elicitation.

Factors	Source	Factors	Source
Increase sensitivity in elicitation practices	[13]	Decision making	[16]
Communication problems	[13]	Stakeholders acceptance	[16]
Rules	[13-14, 16]	Organizational strategies	[14]
Culture	[13-14, 16]	Availability of users	[14]
Technical reasons	[20]	Stakeholders commitment	[14]
Business management factors	[20]	Social climate	[14]
Motivation	[13-14]	Domain knowledge	[14]
Elicitation practices knowledge	[13-14]	Different points of view of the stakeholder	[14]
Experience in IT	[16]	Geographical distribution	[13, 21]
Experience in the business	[16]	Knowledge exchange capability	[22-23]

Table 2. Factors that influence a particular activity in the requirements elicitation process.

Activity	Factors	Source
Knowledge acquisition	Knowledge acquisition, Domain knowledge, Facilitator in communication and Knowledge negotiation	[16]
Find sources	Bulky information sources	[15]
Define technique	Elicitation technique	[13, 14, 16]
Identify wish list	Collaboration, Incomplete understanding of requirements, Stakeholder's commitment, Communication, Elicitation practices knowledge, Different points of view of the stakeholder, Availability of users, Negotiation, Ambiguities, Complexity, Obstacles in interaction, Volatile requirements, Tacit assumptions, Type of language and Gamification.	[13-15, 17, 24, 25]

Besides, in the previous research [19], the literature review was done to identify activities that are related to factors that can affect the requirement elicitation as well. Where the following factors were found: automation, knowledge, collaboration, utilization, communication, stakeholders, business objectives, different stakeholders' views and complexity of the project.

2.3. Motivation

In recent years, different proposals on factors that affect requirements elicitation (Table 1 and 2) have emerged. Despite this, the present work is justified for the following reasons: i) It is important to know the factors that affect the elicitation in general, but, it is more important to know what factor affects which particular activity, since the quality of the elicitation will depend on all the activities being carried out correctly. For example, identifying a factor that affects a particular activity could facilitate its correction at the appropriate time. ii) As shown in Table 2, factors that affect some activities of the elicitation process have been identified, however, there are activities that have not been studied, but are important in the elicitation process and, therefore, in the quality of the requirement. For instance, the activity "integration" allows negotiating, group and ordering the different requirements captured by the stakeholder, eliminating redundancies of repeated

requirements and instead reuse them. iii) Furthermore, although the latest studies [13, 14, 17] show that there are factors that affect elicitation, these studies show evidence that there could be new factors that affect the elicitation process. For example, "Permanent staff" undoubtedly influences all activities, because continuous changes in personnel imply more time and cost to each one of the activities of the elicitation process and, consequently, will affect the quality of the requirement. The purpose of this research is to identify new factors that influence each activity of the requirements elicitation process and, consequently, in quality, for that reason a model with new factors related to the activities of the elicitation process and their respective hypotheses is proposed.

3. New Factors Identified

In this section, seven new factors that influence the activities of the requirements elicitation process are identified and sustained.

3.1. Activities

Based on the review of the literature, a series of activities have been identified for the requirements elicitation process [4, 8-10] (Table 3), some with different names, but with the same meaning, for example, Find sources [9] and Identify sources of requirements [8]; and others that overlap, for example, Identify requirements of sources [4] is the same as the collect wish list of stakeholder [8] and define non-functional requirements [8].

Table 3. Activities of the elicitation process of literature.

Activities	[9]	[4]	[8]	[10]
1	Domain knowledge acquisition			
2	Find sources	Find sources of requirements	Identify sources of requirements	Sources of requirements
3	Define Technique			Requirements technique
4		Identify requirements of sources	Collect wish list of stakeholder	
			Define non-functional requirements	
5			Integrate requirements	
6			Documentation	
7		Documentation	Documentation	

Based on the identified activities, for the present work, we have considered the activities knowledge acquisition, find sources, define technique, identify wish list, integrate wish list, documentation and refinement which, as a whole, cover the entire process of elicitation and that do not overlap one another (see Table 4).

Each activity is important in the elicitation process, not doing one of them does not guarantee that the requirement is of good quality. For example, carrying out the

activity Identify wish list of the stakeholder, without considering the activity define technique, could cause incomplete, incorrect and incomprehensible requirements.

Table 4. Activities of the elicitation process considered for the model.

Id	Activities	Definition	Source
A1	Knowledge acquisition	Domain knowledge acquisition that the analyst needs about the type of project to be developed, which will allow inferring the tacit knowledge that the stakeholders do not articulate and will also allow evaluating the advantages and disadvantages that will be necessary for the requirements in conflict.	[9]
A2	Find sources	Identify all types of potential sources that the analyst needs in order to identify stakeholder requirements because the requirements can come from different sources (users, systems, documents, database, among others).	[4, 8-10]
A3	Define technique	Choose the right technique, method, tool or approach for the requirements elicitation process so as to express the users' needs (for example, interviews).	[9, 10]
A4	Identify wish list	Identify the stakeholders' needs: capture the requirements of the users from the identified sources with the appropriate elicitation technique.	[4, 8]
A5	Integrate wish list	Consolidate the different requirements captured by the stakeholder, group, order, prioritize them, eliminating the redundancies of repeated requirements, and reuse them instead.	[8]
A6	Documentation	Document or specify the information obtained from the stakeholder's requirements.	[8]
A7	Refinement	Define the process of validation and correction of requirements obtained, being able to identify other requirements.	[4, 8]

3.2. New factors

Seventy theories that have been applied in information systems and human, social, and organizational behaviour have been reviewed, in order to know their relationship with the elicitation process, discarding those that had no relationship. Then, the factors that affect the process were identified based on these theories and other sources, several of them already identified in the literature, obtaining seven new factors that we describe below.

The learning capacity factor (F1) refers to the way in which individuals and organizations are able to recognize, absorb and use knowledge [26]. It is relevant in the requirements elicitation because both the stakeholder and the analyst must have the capability to learn new tasks, methods, rules and knowledge related to the type of project to be developed, thus preventing the requirements to be obtained incorrectly, which would cause delays in the development of the project. On the other hand, the organizations with the best results are those that emphasize the learning capacity of their team at all levels of the organization (organizational learning theory [27]), which is why the learning capacity will allow better results in the requirements elicitation process. It should be noted that the factor "Knowledge exchange capability" [22, 23] refers to the ability of the members of a team to share and exchange information, which is different from the "learning capacity".

The negotiation capacity factor (F2) refers to the ability to create an environment that allows collaboration and helps to achieve lasting commitments that strengthen the relationship, by applying the appropriate negotiation technique [28]. It is relevant in requirements elicitation, given that the analyst must have the ability to negotiate with the stakeholders without causing them to be in a conflict, for example, by reaching a mutual agreement, rapidly and using the appropriate persuasion technique, in order to establish which requirements will be prioritized according to the scope and budget of the project. On the other hand, the development of distinctive capabilities will allow companies to achieve competitive advantages (The Theory of the Growth of the Firm [29]) and, if the analyst has good negotiation abilities (Argumentation Theory [30]) with the stakeholder, a good development of the requirements elicitation process will happen.

The permanent staff factor (F3) refers to the permanence of the staff in a work centre or company [31]. It is relevant in requirements elicitation, since if there are no analysts and stakeholders who work in the company in a stable manner, the elicitation process might not be carried out properly, causing long-lasting tasks, because new analysts and new stakeholders must learn the problem's domains and other type of knowledge, affecting the quality of the requirements. Moreover, Pugh [31] argues that there are 14 principles of management that influence organizational behaviour, and one of them is Permanent staff (organizational behaviour theory [31]), this is why having stable personnel (stakeholders and analysts) will allow better results in the requirements elicitation process.

The perceived utility factor (F4) refers to the degree to which a person believes that the use of particular software could improve their performance at work [32]. It is relevant in requirements elicitation since the stakeholders must know the utility that will be obtained by investing their time and collaboration with the analyst, that is, the stakeholders must know what the benefits will be when they use the software that is being developed. On the other hand, when users are introduced with a new technology, a series of factors influence on their decision about how and when they will use it and what benefits they will obtain from it (TAM [32]), it is for this reason that the utility perceived by the stakeholders will allow better results in the requirements elicitation process.

The confidence factor (F5) refers to the confidence that someone has in others who will then behave in a predictable manner and which is based on a circular relationship of risk and action. It is the confidence that someone has in another person or in something [33]. It is relevant in the requirements elicitation process since the stakeholder must have enough confidence in the analyst so that they can establish a good relationship and, therefore, obtain the appropriate information. Moreover, Coleman [34] argues that the aspect of social organization, such as trust, norms and commitment networks, can improve the efficiency of a society by facilitating coordinated action (human capital theory [34]), therefore, confidence would contribute to an efficient requirements elicitation process.

The stress factor (F6) Melgosa refers to the set of physiological and psychological reactions that the organism undergoes when it is subjected to strong demands [35]. It is relevant in requirements elicitation since if there is any stressful situation at the workplace of the stakeholder or analyst, this will affect negatively the productivity of their tasks and, therefore, the quality of the

requirements. On the other hand, according to Susan et al. [36], many events in life have the property of being factors that cause stress, which cause an emotional imbalance. This occurs when the person finds a threatening situation, whose magnitude exceeds their own coping resources, which endangers their well-being and, consequently, the productivity of their work. In addition, stress influences the people's capabilities (Selye's General Adaptation Selye Syndrome [36]). For this reason, stress affects negatively the requirements elicitation process and, consequently, the quality of it.

The semi-autonomous factor (F7) refers to the possibility of acting and thinking without depending on the desire of others [37]. It is relevant in requirements elicitation since it would increase the efficiency of this task, facilitating, for example, the documentation of the elicitation through some semi-autonomous tool, so that no one would depend entirely on the analyst. Moreover, Latour [38] considers both humans and objects (non-humans) as actants, and points out the importance of technology, treating it in a way that is equivalent to the way "social" is treated (actor-network theory [38]). That is why autonomy is important in the requirements elicitation process.

Table 5 shows the summary of the factors identified in the conceptual model with their respective justification.

Table 5. Factors identified.

Id	Factor	Definition	Justification
F1	Learning capacity	How individuals and organizations are able to recognize, absorb and use knowledge [26].	Organizational learning theory [27].
F2	Negotiation capacity	Attitude or sufficiency to negotiate and reach an agreement [30].	The theory of the growth of the firm [29], Argumentation theory [30].
F3	Permanent staff	Permanence of staff in a work centre [31].	Organizational behaviour theory [31].
F4	Perceived utility	Degree to which a person believes that the use of a particular system could improve their performance at work [32].	TAM [32].
F5	Confidence	Confidence that someone has in another person or in something [33].	Social capital theory [34].
F6	Stress	A set of physiological and psychological reactions that the organism undergoes when it is subjected to strong demands [35].	Selye's general adaptation syndrome [36].
F7	Semi-autonomous	Possibility of acting and thinking without depending on the desire of others [37].	Actor-network theory [38].

3.3. Hypotheses

After identifying the factors and activities, the relationships between them were established and, in order to fulfil the objective of the research, 17 hypotheses were formulated as shown in Fig. 1.

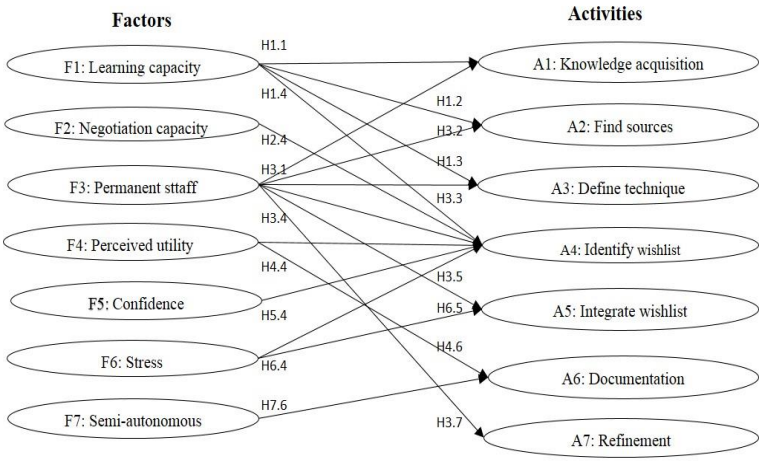

Fig. 1. Initial conceptual model.

3.3.1. Influence of the learning capacity factor (F1)

Considering that the analyst must have the capacity to learn new knowledge related to the type of project to be developed, and, in order to perform well the domain knowledge acquisition activity and obtain the tacit knowledge that stakeholders do not articulate [9], the learning capacity factor will affect positively the activity Knowledge acquisition.

- Hypothesis H1.1: The "Learning capacity" factor influences the activity "Knowledge acquisition" of the elicitation process. Also, the analyst must have the ability to learn how to identify the appropriate sources, such as software, users, documents related to the project, experiences of other people, etc. [9]. The learning capacity factor will affect positively the activity determination of sources of the requirements.
- Hypothesis H1.2: The "Learning capacity" factor influences the activity "Find sources" of the elicitation process. In addition, the analyst must have the ability to learn the different techniques that must be used in order to capture the requirements depending on the type of project that will be developed [10]. The learning capacity factor will affect positively the activity definition of techniques for requirements.
- Hypothesis H1.3: The "Learning capacity" factor influences the activity "Define technique" of the elicitation process. And given that the analyst must have the ability to learn from the needs and experiences of the stakeholder, to adequately identify the sources' needs and with the appropriate elicitation technique [4], the learning capacity will affect positively the activity identification of wish list of the stakeholder.
- Hypothesis H1.4: The "Learning capacity" factor influences the activity "Identify wish list" of stakeholders of the elicitation process.

3.3.2. Influence of the negotiation capacity factor (F2)

Considering that the analyst must have a good negotiation capability with the stakeholders without causing them to be in a conflict, and using the appropriate

negotiation technique to agree on the requirements that will be developed according to the scope of the project [28], the Negotiation capacity factor will affect positively the activity identification of wish list of the stakeholders. This factor is not related to the other activities because only in this activity negotiation is required.

- Hypothesis H2.4: The "Negotiation capacity" factor influences the activity "Identify wish list" of stakeholders of the elicitation process.

3.3.3. Influence of the permanent staff factor (F3)

It is necessary that both the stakeholder and the analyst are stable personnel in the company and thus not affect the activities of the requirements elicitation process [31]. This would avoid the need of hiring new personnel who would require extra time for training, thus affecting the quality of the requirements elicitation. Therefore, this factor will affect positively all the activities of the elicitation process, except for the activity Documentation, which has not been considered because this activity can be carried out through an automatic processor by using some tool.

- Hypothesis H3.1: The "Permanent staff" factor influences the activity "Knowledge acquisition" of the elicitation process.
- Hypothesis H3.2: The "Permanent staff" factor influences the activity "Find sources" of the elicitation process.
- Hypothesis H3.3: The "Permanent staff" factor influences the activity "Define Technique" of the elicitation process.
- Hypothesis H3.4: The "Permanent staff" factor influences the activity "Identify wish list" of stakeholders of the elicitation process.
- Hypothesis H3.5: The "Permanent staff" factor influences the activity "Integrate wish list" of stakeholders of the elicitation process.
- Hypothesis H3.7: The "Permanent staff" factor influences the activity "Refinement" of requirements of the elicitation process.

3.3.4. Influence of the perceived utility factor (F4)

It is important that the stakeholders know what the utility will be when they invest their time and collaborate with the analyst in the requirements elicitation process [32], that is, the stakeholders must know what the benefits will be when they use the software that is being developed. Therefore, this factor will affect positively the following activities of the elicitation process: Identification of the wish list of stakeholders and Documentation of the requirements elicitation.

- Hypothesis H4.4: The "Perceived utility" factor influences the activity "Identify wish list" of stakeholders of the elicitation process.
- Hypothesis H4.6: The "Perceived utility" factor influences the activity "Documentation" of the requirements elicitation of the elicitation process.

3.3.5. Influence of the confidence factor (F5)

It is important that the stakeholder has a good level of confidence in the analyst so that a good relationship between them can be established and appropriate information can be obtained [33]. The Confidence factor will affect positively the activity Identify wish list of stakeholders.

- Hypothesis H5.4: The “Confidence” factor influences the activity “Identify wish list” of stakeholders of the elicitation process.

3.3.6. Influence of the stress factor (F6)

It is important to know if there are any stress issues regarding the stakeholder’s and the analyst’s workplace since this factor could affect negatively the quality of the identification and integration of the wish list of the stakeholders [35]. The Stress will negatively affect the activities Identification and Integration of the stakeholder's wish list.

- Hypothesis H6.4: The “Stress” factor influences the activity “Identify wish list” of stakeholders of the elicitation process.
- Hypothesis H6.5: The “Stress” factor influences the activity “Integrate wish list” of stakeholders of the elicitation process.

3.3.7. Influence of the semi-autonomous factor (F7)

It would be very useful that the documentation or specification of requirements elicitation is carried out without depending on the analyst, through some semi-autonomous tool [38] and, in this way, speed up the time of the documentation. Therefore, the Semi-Autonomous factor will affect positively the activity Documentation of the requirements elicitation process.

- Hypothesis H7.6: The "Semi-Autonomous" factor influences the activity "Documentation" of the requirements elicitation process.

Table 6 shows a summary of the 17 proposed hypotheses, denoted by *H.x.y*, meaning, "Factor *Fx* influences the activity *Ay*". In summary, in Fig. 1, the seven identified factors and their relationships (hypothesis) are conceptualized with the activities of the elicitation process.

Table 6. Hypothesis matrix: Factor vs. activities.

Factors	Activities						
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**
F1	H1.1	H1.2	H1.3	H1.4			
F2				H2.4			
F3	H3.1	H3.2	H3.3	H3.4	H3.5		H3.7
F4				H4.4		H4.6	
F5				H5.4			
F6				H6.4	H6.5		
F7						H7.6	

4. Methodology

4.1. Data collection

In the present investigation, we used a questionnaire as a study instrument. For this reason, an online survey was developed with Google Forms [39] based on the proposed model. The survey was applied to systems analysts and requirements engineers who work at software development companies in Peru, from September to December 2016. The objective of the survey was to determine the perception of the analysts who capture the requirements, in relation to the factors that influence the

activities of the elicitation process. In addition, this survey also considered the relationship of the activities of the elicitation process with the qualities that the activities must fulfil in order to obtain requirements of a proper quality, which is the object of another study. The survey was structured in 3 sections: i) general data of the organization (7 questions), ii) perception of factors that influence the activities of requirements elicitation (8 questions) and iii) perception of activities of the elicitation process that relate to the qualities of requirements (9 questions). For this study, only the first two sections are considered. The questions in section 2 were evaluated with the Likert scale according to a rating of five values (1: Does not influence, 2: Low influence, 3: Medium influence, 4: High influence, 5: Very high influence).

After preparing the survey, a pilot test was carried out to validate the questions. This pilot test was carried out by four senior analysts and a Ph.D., who checked if the questions were properly related to the hypotheses. The wording of the questions was corrected and the use of proper language was reviewed.

Letters and emails were sent inviting participation in the survey to the Peruvian Association of Software Producers (APESOFT), to public institutions, private companies that have an IT department, four software development companies not associated with APESOFT, 30 undergraduate students of the last term and 40 postgraduate students of the Faculty of Systems Engineering and Information Technology of the National University of San Marcos, who work at public and private institutions, obtaining 190 surveys, of which 8 were discarded for having incongruent answers.

4.2. Results analysis

The instrument for the analysis of the data was the questionnaire, thus, the following statistical analyses were performed on the data obtained: i) Reliability of data (reliability test using Cronbach's Alpha), ii) Descriptive analysis of the population (Analysis of demographic aspects of the survey: type of company, level of experience of the respondent, mean, variance, mode and the distribution of respondents' responses), iii) Simple correspondence analysis (analysis to know the degree to which a factor relates to an activity), iv) Multiple correspondence analysis (analysis to know the degree to which a factor is associated with more than one activity) and v) Hypothesis test (Student's t-test used to verify the hypotheses).

5. Results and Discussion

5.1. Reliability of data

To estimate the reliability of the measuring instrument, Cronbach's Alpha has been used. The closer the value of alpha is to 1, the greater is the internal consistency of the elements analysed, and the validity of an instrument is acceptable if it has a value above 0.70 [40]. According to the results obtained with the R tool, a value of Cronbach's Alpha equal to 0.95 was obtained (see Fig. 2).

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Reliability analysis
 raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd
      0.95      0.95    0.98       0.3  20 0.005  4.5 0.34
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Fig. 2. Results with R on the reliability of the survey data.

5.2. Descriptive analysis of the population

Table 7 shows the classification of respondents' answers according to the type of company and the type of experience. The experience of the respondent has been classified into three types: Junior (between 1 and 2 years of experience), Semi senior (between 2 and 4 years of experience) and Senior (more than 4 years of experience). As shown below, 52% of the respondents come from software development companies, 28% come from private companies and 20% come from public institutions. 82% of the respondents are senior and semi-senior.

The mean, variance and mode of the respondents' responses were calculated regarding the perception in relation to the factors that influence the activities of the elicitation process (see *Appendix A*). As shown, the average of the mean of the respondents' perception is greater than four meaning that the factors have a high influence.

Table 7. Classification of respondents.

Company type	Experience	Frequency (N=182)		Percentage
Private company	Junior	6	51	28%
	Semi senior	25		
	Senior	20		
Public institution	Junior	3	36	20%
	Semi senior	25		
	Senior	8		
Software company	Junior	23	95	52%
	Semi senior	44		
	Senior	28		

For the descriptive analysis of the population, boxplot has also been used, which allows to graphically show how the data is distributed. In Fig. 3, some Boxplot related to the answers of the respondents among the factors and activities are presented. As shown, the qualification of the respondents on the influence of the factors in the activities has a value greater than four (high influence). For instance, in Fig. 3(a), the qualification of the respondents on the influence of Factor 1 and the activities for A1, A2, A3 and A4 have a median equal to 4 (high influence) and are distributed in the same way (there are no differences between activities).

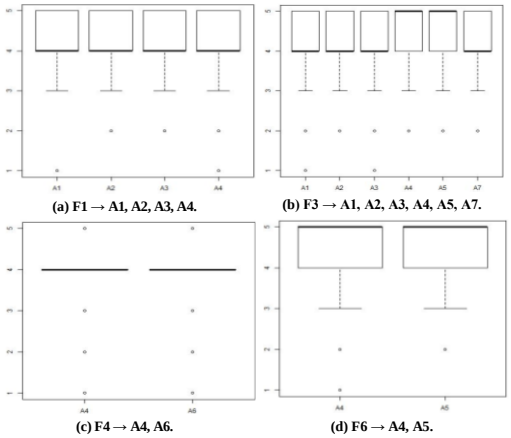


Fig. 3. Some boxplot of the influence of factors in activities.

5.3. Simple correspondence analysis (CA)

The purpose of this analysis is to know the degree to which each proposed factor is associated with each activity of the requirements elicitation process. Table 8 shows the eigenvalues for the calculation of the CA between the factors and activities, where the value associated with the variance (value) and the percentage of variance for each component (percentage) is observed. The first two components can explain 82.85% of the data in the sample (57.67% + 25.18%), therefore, components 1 and 2 (Dim1 and Dim2) were used and with these values, the tables of inertia were constructed, which are shown in Tables 9 and 10.

Table 8. Eigenvalues for the CA between the factors and activities.

Component	1	2	3	4	5	6
Value	0.866	0.378	0.199	0.0589	0.000	0.000
Percentage (%)	57.67	25.18	13.24	3.92	0	0

To graphically represent (by the plot) the association of the factors with the activities, the tables of inertia were constructed: rows (activities) and columns (factors) are shown in Tables 9 and 10. Table 9 shows the degree of contribution of each activity to each of the components (Dim1 and Dim2), it also shows to which component is related more to each activity, the total frequency of each point (Mass), the value of the chi-square distribution (ChiDist) and the value of inertia (inertia).

Similarly, Table 10 shows the degree of contribution of each factor to each of the components and shows to which component each factor is related.

Table 9. Table of inertia of activities.

Activity	A1	A2	A3	A4	A5	A6	A7
Mass	0.097	0.097	0.099	0.426	0.147	0.079	0.056
ChiDist	0.938	0.922	0.946	0.659	1.081	3.178	1.293
Inertia	0.086	0.083	0.088	0.185	0.171	0.794	0.093
Dim.1	-0.376	-0.376	-0.376	-0.206	-0.339	3.412	-0.376
Dim.2	1.374	1.360	1.381	-0.896	-0.612	0.229	0.918

Table 10. Table of inertia of factors.

Factor	F1	F2	F3	F4	F5	F6	F7
Mass	0.201	0.101	0.374	0.043	0.057	0.173	0.052
ChiDist	0.948	1.162	0.598	2.101	1.162	1.025	3.422
Inertia	0.181	0.136	0.134	0.189	0.076	0.182	0.603
Dim.1	-0.350	-0.221	-0.350	2.241	-0.221	-0.284	3.667
Dim.2	1.141	-1.458	0.564	-0.299	-1.458	-1.257	0.373

For the design of the plot graphic (Fig. 4), the influence of the factor on the activities is being considered, with the value "1" (if it influences) when the qualification of the respondents is equal or greater than 4 and, if not, value "0" (does not influence). This graph shows, visually, which factors (red triangles) are

related to the activities (points in blue), that is, the closer two points are, the more related they are.

In Fig. 4, we observe the following: i) factor F1 relates to activities A1, A2, A3, A4, ii) factor F2 relates to activity A4, iii) factor F3 relates to activities A1, A2, A3, A4, A5, A7, iv) factor F4 relates slightly to activity A6 and relates distantly to activity A4, v) factor F5 relates to activity A4, vi) F6 relates to activities A4 and A5 and vii) factor F7 relates to activity A6.

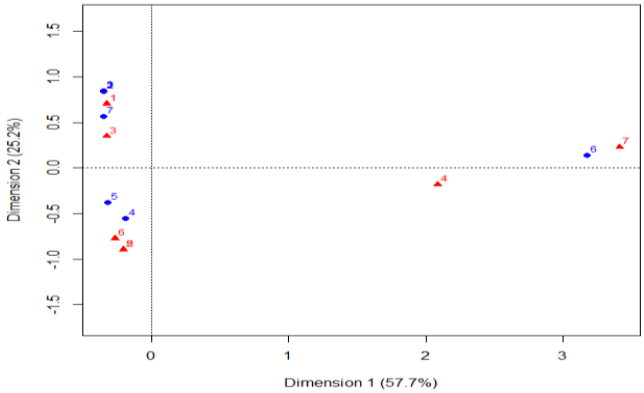


Fig. 4. Simple correspondence analysis between factors and activities.

5.4. Multiple correspondence analysis (MCA)

This section shows the results of the Multiple Correspondence Analysis (MCA) carried out among the factors that affect more than one activity of the requirements elicitation process (see Table 11).

Table 11. MCA relationships between factors and activities.

Factor		Activities
F1	→	A1, A2, A3, A4
F3	→	A1, A2, A3, A4, A5, A7
F4	→	A4, A6
F6	→	A4, A5

5.4.1. Influence of learning capacity (F1 → A1, A2, A3, A4)

Figure 5 shows the distribution of the respondents' ratings on the perception of the level of influence of the learning capacity factor (F1), in the activities of knowledge acquisition (A1), find sources (A2), define technique (A3) and identify wish list (A4). Notice that these qualifications are separated into two groups: i) blue group: high scores (5, 4 and 3) and ii) red group: low scores (1 or 2).

Respondents' perception of the level of influence of the learning capacity factor (F1), on the activities of knowledge acquisition (A1), find sources (A2), define technique (A3) and identify wish list (A4), on average, reach more than 93% for scores 4 and 5 ("high influence" and "very high influence"), as shown in Table 12.

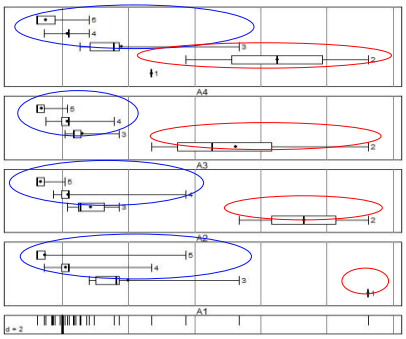


Fig. 5. Distribution of scores of the F1 influence with A1, A2, A3 and A4.

Table 12. Perception of respondents on the level of influence between F1 and A1, A2, A3, A4.

Relation	Score				
	1	2	3	4	5
H1.1	0.01	0.00	0.03	0.60	0.36
H1.2	0.00	0.01	0.06	0.58	0.35
H1.3	0.00	0.02	0.07	0.54	0.37
H1.4	0.01	0.01	0.04	0.49	0.45

In addition, in Fig. 6, the first factorial map of the MCA is shown: the scores of all the activities (upper-left) regarding the F1 factor, the 182 surveyed (upper-right), the scores and the respondents simultaneously (lower-left) and the projection of companies superimposed with the scores (lower-right).

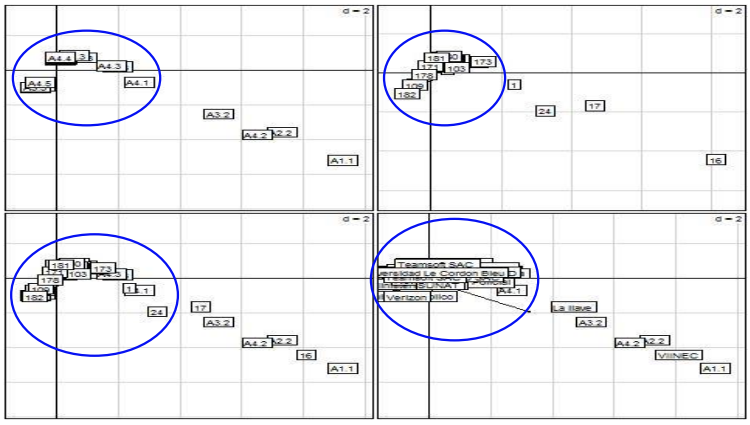


Fig. 6. Factorial map of the MCA between F1 and A1, A2, A3 and A4.

Also, from the main associations we can see the following: scores 5, 4, 3 of all the activities (A1, A2, A3, A4) that are strongly associated (upper-left), respondents indicate that these activities influence the F1 factor (bottom-left) and, finally, companies indicate that these activities influence the F1 Factor (lower-right). In the same way, the MCA has been made of the other relationships.

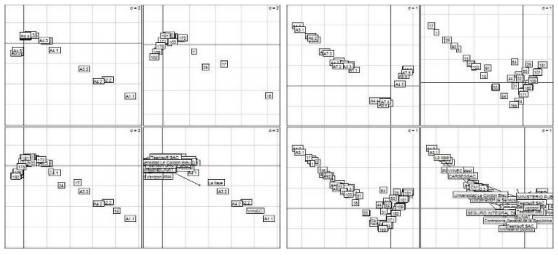
5.4.2. Other relationships (F3, F4, F6)

Similarly, in Table 13, we can observe the respondents' perception of the level of influence of the "permanent staff" factor (F3) on the activities knowledge acquisition (A1), find sources (A2), define technique (A3), identify wish list (A4), integrate wish list (A5) and refinement (A7), which on average, reach more than 92% for scores 4 and 5 ("high influence" and "very high influence"). The respondents' perception of the level of influence of the "perceived utility" factor (F4) on activity identify wish list (A4), which on average, reaches 78% for scores 4 and 5 ("high influence" and "very high influence") and 84% on the activity documentation (A6). And the respondents' perception of the level of influence of the "stress" factor (F6) on the activity identify wish list (A4), which on average, reaches 94% for scores 4 and 5 ("high influence" and "very high influence") and 92% on the activity integrate wish list (A5).

In summary, in Fig. 7, the factorial maps of the multiple correspondence analysis performed on the four factors are shown: learning capacity in Fig. 7(a), permanent staff, Fig. 7(b), perceived utility, (Fig. 7(c) and stress, Fig. 7(d).

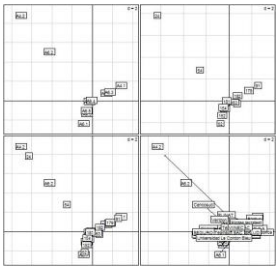
Table 13. Perception of respondents on the level of influence of F3, F4, F6.

MCA	Hypothesis	Score				
		1	2	3	4	5
F3 → A1, A2, A3, A4, A5, A7	H3.1	0.01	0.01	0.04	0.56	0.38
	H3.2	0.00	0.02	0.07	0.52	0.39
	H3.3	0.01	0.03	0.08	0.50	0.38
	H3.4	0.00	0.02	0.04	0.20	0.74
	H3.5	0.00	0.01	0.05	0.40	0.54
	H3.7	0.00	0.02	0.05	0.50	0.43
F4 → A4, A6	H4.4	0.01	0.01	0.20	0.66	0.12
	H4.6	0.01	0.02	0.13	0.63	0.21
F6 →A4, A5	H6.4	0.01	0.02	0.03	0.20	0.74
	H6.5	0.00	0.03	0.05	0.34	0.58

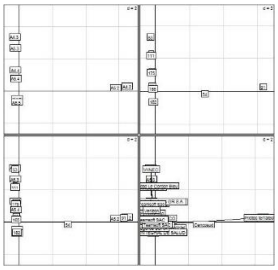


(a) F1 → A1, A2, A3, A4.

(b) F3 → A1, A2, A3, A4, A5, A7.



(c) F4 → A4, A6.



(d) F6 →A4, A5.

Fig. 7. Factorial maps of the MCA of F1, F3, F4 and F6.

5.5. Hypothesis test

In this section, the T-Student distribution has been applied [41] in order to verify the hypotheses proposed in section 3. To do this, the null hypothesis (H_0) and the alternative hypothesis (H_a) were first formulated, so that the alternative hypothesis has mathematically stated what we want to demonstrate and the null hypothesis H_0 poses exactly the opposite. The alternative hypothesis will be the one that is accepted if H_0 is rejected and vice versa. For this, the null hypothesis H_0 and the alternative hypothesis H_a were defined with the following decision rules:

- $H_0 = \mu < 4$ (Respondents believe that the degree of influence of the factor on activity is less than 4).
- $H_a = \mu > 4$ (Respondents believe that the degree of influence of the factor on the activity is greater than 4).

To accept or reject the null hypothesis H_0, the probability of error (p-value) was calculated by means of Eq. (1) proposed by Gosset [41]. The value of the level of significance (α) for this study is 0.05. If the probability of error (p-value) is greater than the level of significance (α), the null hypothesis H_0 is accepted and, therefore, the alternative hypothesis H_a is rejected. If the probability of error (p-value) is lower than the level of significance (α), the null hypothesis H_0 is rejected and, therefore, the alternative hypothesis H_a is accepted.

$$t = (\bar{X} - \mu)/(s/\sqrt{n}) \quad (1)$$

where "$\bar{X}$" is the mean of the sample, "μ" is the mean specified in the null hypothesis to be analyzed, "s" is the standard deviation of the sample and "n" is the size of the sample.

Table 14 shows the results of the T-Student hypothesis test that has been made to the hypotheses between "factors" vs. "activities" according to Eq. (1). It also shows the hypotheses, the calculated value of *t*, the degree of freedom (*df*), the probability of error (*p-value*), the percentage of *confidence*, the minimum and maximum estimated values of the *mean* and the *acceptance* or *rejection* of the null hypothesis H_0.

Table 14. Summary of T-students hypothesis tests.

Hypothesis	t	Df	p-value	Confidence	Estimated Mean		Result
					Min	Max	
H1.1	7.1532	181	1.016e-11	95	4.2408	4.313187	Support
H1.2	5.8485	181	1.137e-08	95	4.193122	4.269231	Support
H1.3	5.2434	181	2.183e-07	95	4.180577	4.263736	Support
H1.4	7.6531	181	5.644e-13	95	4.297219	4.379121	Support
H2.4	21.113	181	< 2.2e-16	95	4.693802	4.752747	Support
H3.1	6.1954	181	1.908e-09	95	4.221552	4.302198	Support
H.3.2	5.62	181	3.558e-08	95	4.201661	4.285714	Support
H.3.3	4.2285	181	1.864e-05	95	4.143887	4.236264	Support
H.3.4	14.166	181	< 2.2e-16	95	4.587244	4.664835	Support
H.3.5	10.267	181	< 2.2e-16	95	4.401044	4.478022	Support
H.3.7	6.9617	181	2.99e-11	95	4.259757	4.340659	Support
H.4.4	-2.3873	181	0.991	95	3.814005	3.89011	No support
H.4.6	0.32459	181	0.3729	95	3.932525	4.016484	No support
H.5.4	8.6534	181	1.334e-15	95	4.311131	4.384615	Support
H.6.4	13.584	181	< 2.2e-16	95	4.588743	4.67033	Support

H.6.5	8.9768	181	< 2.2e-16	95	4.38998	4.47802	Support
H.7.6	4.8027	181	1.636e-06	95	4.172945	4.263736	Support

As shown, in most cases (H.1.1, H.1.2, H.1.3, H.1.4, H.2.4, H.3.1, H.3.2, H.3.3, H.3.4, H. 3.5, H.3.7, H.5.4, H.6.4, H6.5 and H7.6), the value of the error probability (p-value) is less than 0.05 ($p<0.05$), then the alternative hypothesis H_a is accepted, so we can say with 95% confidence that the average opinion of the respondents is greater than 4, meaning that the factors have a "high influence" on the activities of the elicitation process. It is also observed that hypotheses H4.4 and H4.6 have not been supported ($p>0.05$) because at 95% confidence the perceived utility (F4) has a "median influence" on the activities identify wish list (A4) and documentation (A6).

The results show, from the simple correspondence analysis (CA) on 17 hypotheses Factor → Activity (see Table 6), that all the factors have a relationship between "High influence" and "Very high influence", at 82.85% of the sample's data. The results also show, from the multiple correspondence analysis (MCA) Factor → Activities (see Table 11), that all relationships have scores between "High influence" and "Very high influence" with an average of 89.95% of responses from respondents, being the strongest relationship learning capacity (F1) → knowledge acquisition (A1), find sources (A2), define technique (A3), identify wish list (A4) with 93.5% (see Table 12) and the weakest relationship perceived utility (F4) → identify wish list (A4), documentation (A6) with 81% (see Table 13).

Hypothesis test (Table 14) confirms 15 relationships of 17 hypotheses, being rejected hypothesis H4.4: perceived utility (F4) → identify wish list (A4) and H4.6: perceived utility (F4) → documentation (A6), this is because in the hypothesis test the average score of "High influence" *($\mu = 4$),* has been considered, this being very demanding, but if the qualification interval *[1.0, 5.0]* had been segmented into equidistant segments, the score 5 ("High influence") would correspond to the interval *[3.4, 4.2]* which would make all the hypotheses valid.

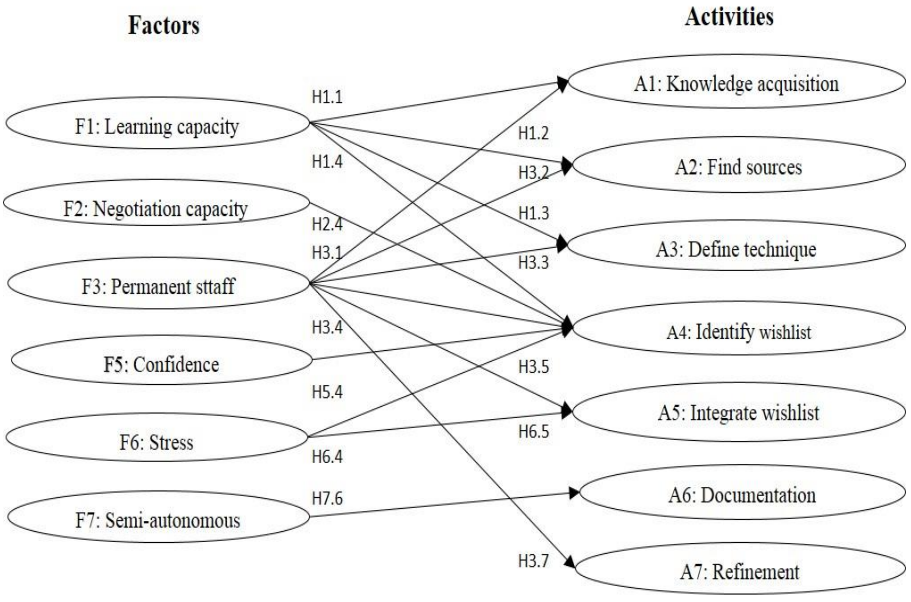


Fig. 8. Final conceptual model.

Finally, the final conceptual model is made up of 6 factors, 7 activities of the requirements elicitation process, and 15 relationships, thus, due to its theoretical sustenance, constitutes a robust model (see Fig. 8).

6. Conclusions

In this work, new factors have been introduced that influence the activities of the requirements elicitation process: learning capacity, negotiation capacity, permanent staff, perceived utility, confidence, stress and semi-autonomous; which have been supported by theories, such as Organizational Learning theory, Organizational Behaviour theory, Self-efficacy theory, Social capital theory, Task closure theory and Actor-network theory. The main conclusions of this investigation are given below:

- There is no standard for the elicitation process. Some authors consider four activities, others 5 activities, some consider activities that others do not consider and others label activities with different names. For this reason, a process of requirements elicitation has been proposed which consists of seven activities that, as a whole, cover the entire process of elicitation and all of these are important since not doing one of them does not guarantee that the requirement is of a good quality.
- Most of others works have identified factors that affect the elicitation process but they do not indicate which particular activity they affect. For that reason, in this work, we have identified what factors affect which activities of the elicitation process.
- The results of a study applied to 182 systems analysts and requirements engineers who work at software development companies in Peru showed, from the simple correspondence analysis (CA) and the multiple correspondence analysis (MCA), that all relationships have scores between "High influence" and "Very high influence".
- Finally, the hypothesis test confirmed 15 relationships of 17 hypotheses, so that, the final conceptual model is made up of six factors, seven activities of the requirements elicitation process, and 15 relationships.

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We would like to thank the public and private institutions and undergraduate and graduate students of the university, who participated in the survey. Also, to the reviewers for their recommendations and opinions.

Nomenclatures

A1	Activity: Knowledge acquisition (Table 4)
A2	Activity: Find sources (Table 4)
A3	Activity: Define technique (Table 4)
A4	Activity: Identify wish list (Table 4)
A5	Activity: Integrate wish list (Table 4)
A6	Activity: Documentation (Table 4)
A7	Activity: Refinement (Table 4)
ChiDist	Value of the chi-square distribution
df	Degree of freedom
Dim1	Component 1 to explain the data of the sample (Table 9 and 10)
Dim2	Component 2 to explain the sample data (Table 9 and 10)
F1	Factor: Learning capacity (Table 5)
F2	Factor: Negotiation capacity (Table 5)
F3	Factor: Permanent staff (Table 5)
F4	Factor: Perceived utility (Table 5)
F5	Factor: Confidence (Table 5)
F6	Factor: Stress (Table 5)
F7	Factor: Semi-Autonomous (Table 5)
H_0	Null hypothesis
H_a	Alternative hypothesis
Mass	Total frequency of each point
n	Size of the sample
p-value	Probability of error
s	Standard deviation of the sample
t	T-Student distribution Eq. (1)

Greek Symbols

α	Level of significance
$\bar{x}$	Mean of the sample
μ	Mean specified in the null hypothesis H_0

Abbreviations

CA	Correspondence Analysis
MCA	Multiple Correspondence Analysis
RE	Requirements Engineering

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Appendix A

Mean, variance and mode of respondents' responses on factors and activities

Hypothesis	Mean	Variance	Mode
H1.1	4.31	0.35	4
H1.2	4.27	0.39	4
H1.3	4.26	0.46	4
H1.4	4.38	0.45	4
H2.4	4.75	0.23	5
H3.1	4.30	0.43	4
H3.2	4.29	0.47	4
H3.3	4.24	0.57	4
H3.4	4.66	0.40	5
H3.5	4.48	0.39	5
H3.7	4.34	0.44	4
H4.4	3.89	0.39	4
H4.6	4.02	0.47	4
H5.4	4.38	0.36	4
H6.4	4.67	0.44	5
H6.5	4.48	0.52	5
H7.6	4.26	0.55	4