A SOUTH AFRICAN PERSPECTIVE OF THE REQUIREMENTS DISCIPLINE: AN INDUSTRY REVIEW

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Abstract: The requirements discipline is at the heart of systems engineering, software engineering and business analysis. Across these three communities common practices, approaches and techniques are available in literature. However, little application data is available on how practitioners apply these common practices during the requirements engineering process in practise. To generate data on how practise carries out the requirements engineering process, a two-part survey was conducted. The first part of the survey is reported here and investigates how practitioners carry out the requirements engineering process. The survey was completed by individuals involved in practice as requirements practitioners. This survey and its results offer opportunities to increase industry relevance of research outcomes and identified focus areas for practitioners, including software system developers, to exploit and increase their effectiveness during requirements activities.

Keywords: Requirements, requirements engineering process, survey

1. INTRODUCTION

It is irrelevant whether a software solution or system is developed or bought. For any software system to be useful to the users and business, the developers must understand what the software solution or system is intended to achieve for the users and business [1]. The purpose of requirements engineering is to maximise the likelihood that a developed or bought solution or maintenance initiative will deliver solutions that function as desired. The requirements discipline has different origins and different approaches to capture requirements during the solution development due to the relevance of requirements of different communities such as systems engineering, software engineering and business analysis. However, an understanding of the problem is always required before the development of a solution [2].
The importance of requirements engineering is acknowledged by the engineering literature [3-5]. Requirements are quoted as the input to the software or systems engineering process. If the requirements delivered during requirements development is not of high quality, the solution derived from the requirements have a risk to not achieve what it was intended for [6-8]. Even the best requirements practices cannot make up for inaccurate requirements [9].

The research community acknowledges the importance of requirements. However, industry itself is still facing many challenges in practice with the requirements engineering process during the delivery of a solution [10]. Industry reports, surveys and research continuously quote poor requirements as the main contributor to failed projects, along with the cost and rework implications of the requirements errors [9, 11-23].

In order to contribute relevant knowledge to the requirements discipline, research focus areas have been highlighted by Cheng and Atlee [24]. One of these focus areas is the importance of collaborative partnerships between researchers and practitioners to increase the industry relevance of research [24-26]. A second focus area highlighted by Cheng and Atlee [24] was to document empirical research on how well requirements engineering research addresses industrial problems.

In response to the focus areas highlighted, the research reported on in this paper was aligned to increase the industry relevance of the research outcomes; the first step of the research undertaken was to gather data on how practitioners apply existing requirements engineering knowledge in practice. Results existed for some of the international industries as per literature [27-29]. For the South African requirements industry, there is little or no recent research data describing how practitioners execute the requirements process.

This paper's main objective is to explore and document how practitioners also focusing on software engineering execute the requirements engineering process, as little shared knowledge within the South African context is available in research. The first section summarises how literature suggests the requirements engineering process should be executed, after which the research design is explained. The results collected to derive a description of how practitioners execute the requirements engineering process are presented. Finally, key findings are summarised from results.

2. LITERATURE REVIEW

A requirement is a collection of capabilities originating from users and stakeholders (organisational, legislation, and industry standards) that all must be met by the solution to solve the problem or achieve the objective [4]. The stakeholders must be involved for the proposed solution to solve the problem or achieve the objective. It is often assumed that the stakeholders already know what the requirements are at the beginning of a problem solution. As far back as the 1970s, Bell and Thayer [30] cautioned that "*requirements for a system, in enough detail for its development, do not arise naturally. Instead, they need to be engineered and have continuing review and revision*".

When a solution is implemented, different engineering process models are available to use and implement a possible solution as discussed in literature [31-36]. During the problem solution process, the assumptions of problem complexity, the availability of knowledgeable users and the type of the required solution have a direct impact on which of the engineering process models would be most appropriate [37].

The selection of an engineering model will impact on how the requirements will be documented. In a small environment, with a rapidly changing marketplace where people are capable and work collaboratively, agile methods would be appropriate and the requirements will be documented less formally [38]. In an environment where people do not work collaboratively, requirements will have to be documented formally to minimise misunderstandings [38].

Although the method of requirements documentation could vary, based on the selected engineering model, the requirements have to be understood to solve the problem. The goals of the requirements engineering process as described by Pohl [39] are:

- Transforming unclear user needs into a complete system specification;
- Transforming informal knowledge into formal representations;
- A common agreement on the specification from the various personal views.

The term "requirements engineering process" is defined as the systematic process of developing requirements through an iterative co-operative process of analysing the problem, documenting the resulting observations in a variety of representation formats and checking the accuracy of the understanding gained [40, 41]. This definition can be illustrated by a model explained by Wiegers [42] that divides the requirements engineering domain into two domains as illustrated in Figure 1.

The initial domain is requirements development to derive a complete user specification. Once the specification is produced, it must be agreed upon by all stakeholders. These are the baseline requirements that will be used to build the solution. Once the baseline requirements have been established and agreed upon, changes should be managed to ensure that all stakeholders stay in agreement. This is presented as the requirements management domain.

The common activities in the requirements development are elicitation, analysis, specification and validation, and change management [4]. These activities are executed in different forms, namely linear, incremental, non-linear, spiral or adaptive processes as discussed by Van Lamsweerde [37], Wiegers [42], Kotonya and Sommerville [43] and Macaulay [44].

Requirements elicitation is the discovery of knowledge about the problem that must be solved [37]. The literature mentions many approaches or techniques to determine the required knowledge [25, 26, 45]. The choice of elicitation technique depends on resource availability, information required and the types of problems that need to be solved.

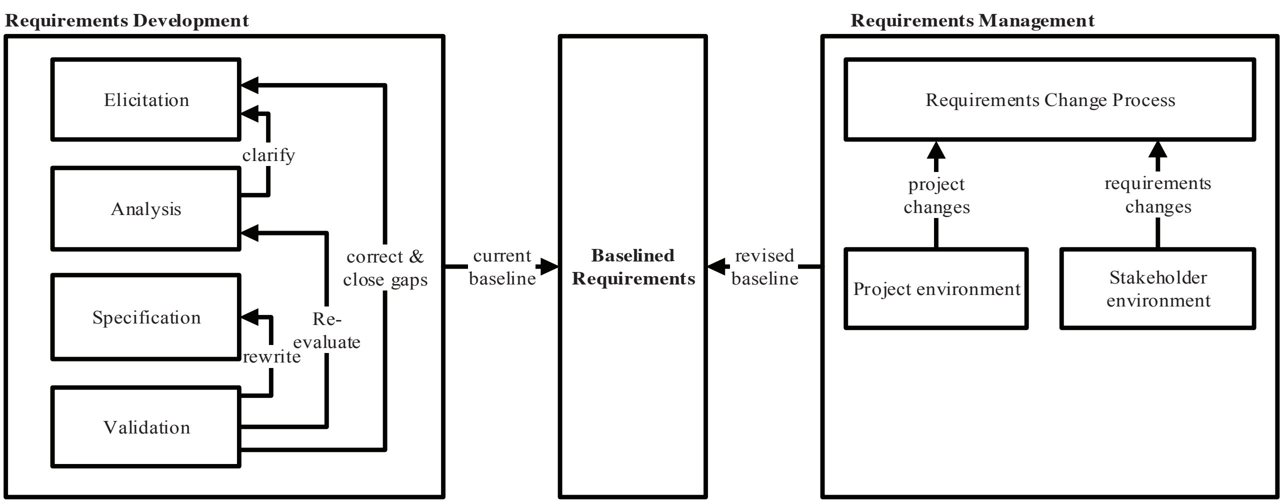

Figure 1: Requirements engineering domain [42]

Guidelines on how to choose the appropriate elicitation technique are provided by Robertson and Robertson [1], Robertson [46], Maiden and Rugg [47] and Zowghi and Coulin [25].

The analysis activity considers all the elicited information and generates a list of potential requirements. The objective of the requirements analysis step is to increase understanding, identify problems and search for inconsistencies in the list of produced requirements [43, 48]. Models are generated to understand requirements. Various modelling techniques or notations are available as discussed by Nuseibeh and Easterbrook [45].

Once all the information has been elicited and requirements have been analysed and modelled, the findings from these two activities should be documented in the specification document. The specification document can be generated in various formats or languages [26, 49]. Many best practice templates are available to provide guidelines on what information should be presented in the specification document [50-52]. Quality elements of a specification have been detailed by standards [51-53].

The output of the requirements development is a set of commonly agreed upon requirements by all stakeholders as presented in the specification document. These form the baseline requirements that will be used to build the solution. The priority of each requirement should be discussed by and agreed upon with the stakeholders to identify the most important requirements with the greatest impact on solving the problem. Techniques that are available are discussed by Berander and Andrews [54], Hansen et al. [26] and Cheng and Atlee [24]. The requirements must be validated for completeness and conflict and should reflect what needs to be done to solve the stakeholders' problem. Once a baseline set of requirements has been agreed upon, requirements must be managed and changes should be analysed based on the impact that they will have on the solution.

Each of the requirements communities also has professional bodies that provide guidelines on how to execute the activities during the requirements engineering process [53, 55, 56].

A summary was presented of knowledge available from literature about the requirements engineering process, the tools, techniques and modelling methods and guidelines. Next an industry review was done to describe how practitioners in South African industries execute the requirements engineering process. This generated knowledge on how the requirements engineering process is executed in practice. This knowledge will be utilised to determine whether the existing requirements engineering knowledge base is actually migrated into practice.

The most appropriate research method had to be used to obtain a description of how the requirements engineering process is executed by practitioners, as well as how practitioners behave during the execution of the process. The research methodology selection is described in the next section.

3. RESEARCH METHODOLOGY

The purpose of the industry review was to provide a description of how the requirements process is performed within the South African requirements engineering community. A survey research method was evaluated as it is characterised as producing quantitative descriptions on some aspects of a studied population, which include the examination of the relationships among different variables [57]. Survey research is appropriate if there is not adequate data available. This is the case with South African requirements practice. The target population of requirements practitioners was accessible and a portion of the data was personal and self-reported data of practitioners [58].

Real-world data was required from as many practising respondents as possible within the requirements discipline in a short time. The strengths of a survey confirmed that a survey would be the appropriate method [57-61]. A rigid systematic approach was followed to ensure that the survey would be conducted rigorously and in an unbiased manner. This process followed is illustrated in Figure 2and has been derived from literature [58, 62, 63].

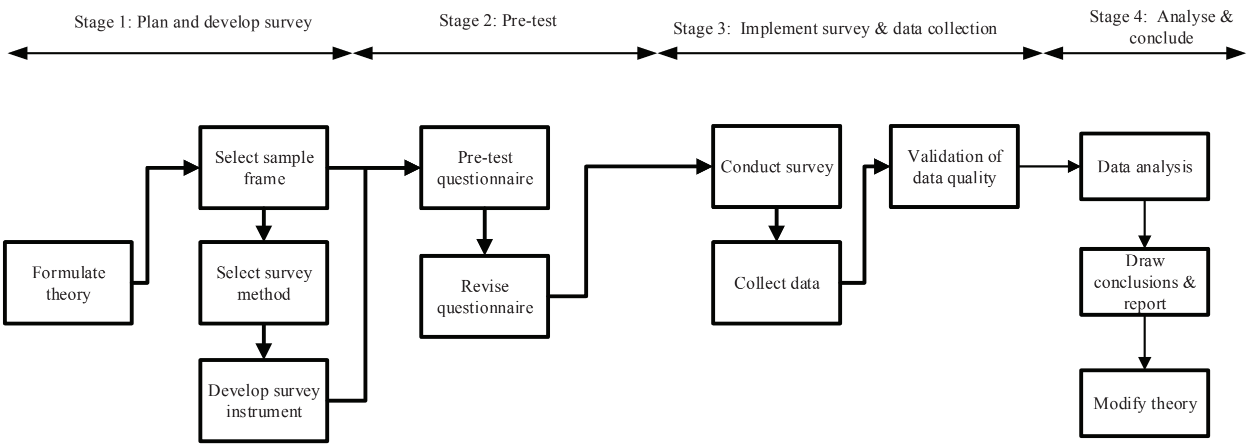

Figure 2: Survey process

3.1 Planning and development of the survey

The objectives of the industry review were to produce a quantitative description of how the requirements process is executed by practitioners, with practitioners belonging to multiple communities. The requirements discipline crosses multiple communities, namely systems engineering, software engineering and business analysis [2]. The review would also determine whether the available tools and methodologies as identified in literature are used or known by the practitioners.

The sample frame refers to how the population was constituted. The factors for consideration to ensure a complete survey design are listed by Fowler [57] and Sapsford [64]. The target population was only practitioners that were responsible for any activities in the requirements engineering process. The requirements practitioners were classified as a difficult-to-reach population as they had not been previously identified [65]. In the case of hard-to-reach populations, snowball, targeted, time space and respondent-driven sampling are suggested to access these hidden populations [66].

Snowball sampling is a very useful methodology to conduct exploratory, qualitative and descriptive research, especially where a high degree of trust is required for initial contact [66]. This sampling makes contact with a small group of relevant people and then uses these contacts to establish new contacts with others [67]. Snowball sampling was selected as the preferred sampling method as the population was difficult to research and a description of the population was the main objective of the industry review [68].

Three different approaches were followed to find respondents within the requirements practitioners' social network and to start the referral chain of the snowball sampling:

- Relationships were established between the researchers and individuals who were either chief information officers to whom requirements practitioners typically reported or individuals responsible for requirements practice. These individuals were contacted prior to the survey to obtain their cooperation. The researcher used multiple individuals with established relationships to start a referral chain within as many organisations as possible.
- A list of individuals practising as requirements practitioners within the industry were known to the researchers. These known practitioners were contacted directly and requested to complete the survey. They were also requested to distribute the survey link to their network of requirements practitioners.
- Two professional organisations were contacted and requested to send the survey to their members. The first professional organisation was Computer Society South Africa, which confirmed that they distributed the survey to all their members that had an interest in requirements practice. The second professional organisation contacted was the International Institute of Business Analysis South Africa. They were requested to send the survey to all their members as their focus is on analysis, which is within the requirements engineering space.

This was done to ensure that the sample frame included a non-homogeneous set of requirements practitioners across the industry and to minimise potential bias which could emerge due to a sample frame that did not fully represent the population [62].

After careful consideration of the advantages and disadvantages of each survey type, the Internet survey type was selected as a collection tool. It enabled the collection of data electronically that would be ready for analysis at a low cost within a very short time. The respondents' confidentiality was also protected. The population coverage would not be impacted by the Internet access as the requirements practitioners normally have Internet access within their work environment.

To explore and document how the practitioners execute the requirements engineering process, data was collected from the first two sections in the survey. The survey questions were based on knowledge collected from previous studies and a literature review [27, 69, 70]. Data was collected to profile the participants and to derive a description of the requirements engineering process. The focus was on the input to the requirements process, requirements activities and the quality of the output of the requirements process.

3.2 Pre-testing

When the questionnaire was completed, it was tested to ensure that it would work under real-life conditions [57]. As it was a self-administered instrument, it was first configured on the online survey platform that would be used to collect the data. Once ready, various pre-tests were done, including survey duration and pilot testing.

3.3 Implementation of survey and data collection

The survey was opened on the Internet via the platform used. The platform service provider was Survey Monkey. The data collection was facilitated by the platform on which the survey was configured. Data was automatically collected in various electronic formats by the platform.

During the design of the questionnaire, elements for good questionnaire design were taken into consideration to address data quality. Additional reliability and validation tests were done to evaluate the survey instrument before implementation.

3.4 Analyse and conclude

Data analysis involved the data collected being reduced and summarised into a usable format and patterns in data being identified [59]. The data analysis followed four stages as described by Quinlan [71]:

- Stage one was to engage in a descriptive analysis of the collected data.
- Stage two was to interpret the data.
- Stage three was to use the results of stages one and two to draw conclusions from the data.
- Stage four was the theorisation stage. In this stage the results from stages one, two and three were used to apply to existing knowledge and produce new theory.

Stages one to three of the data analysis will be discussed in the survey results, as the purpose of this article is to present the application data collected on how practitioners apply common practices during the requirements engineering process.

4. SURVEY RESULTS AND DISCUSSION

A total of 127 responses were received from the requirements practitioners. The main survey results are provided in a graphical format for summary purposes.

4.1 Participant characteristics

The survey respondents were mainly from the finance and banking (33%), ICT (23%) or government public sector and defence industries (9%). Although the majority of respondents were from these industries, the data confirms a presence of requirements practitioners across all industries as illustrated in Figure 3.

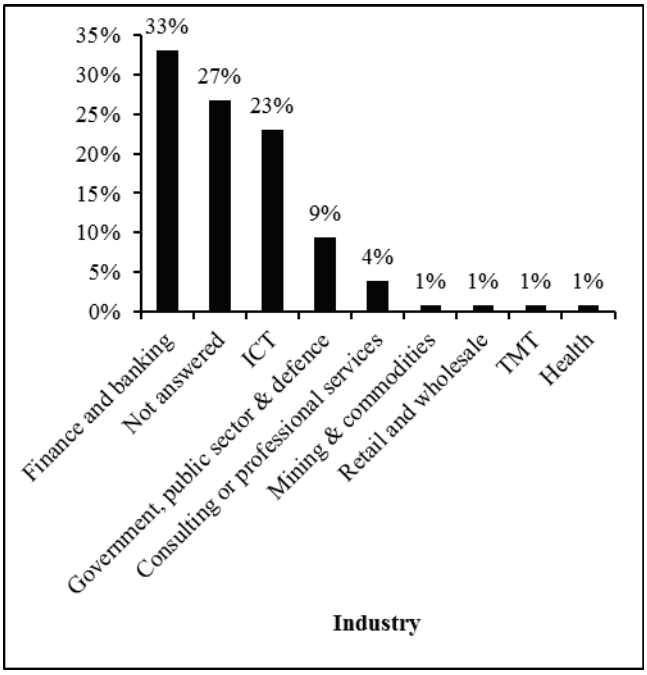

Figure 3: Practitioners' industry background

The requirements practitioners had very diverse job descriptions as summarised in Figure 4. There was, however, one specific job description that was commonly used, i.e. business analyst. This grouping also includes the job description of senior business analyst and constituted 47.2% of the respondents. The 'Other' group of job descriptions ranged from developers, project managers and specialists to programme managers.

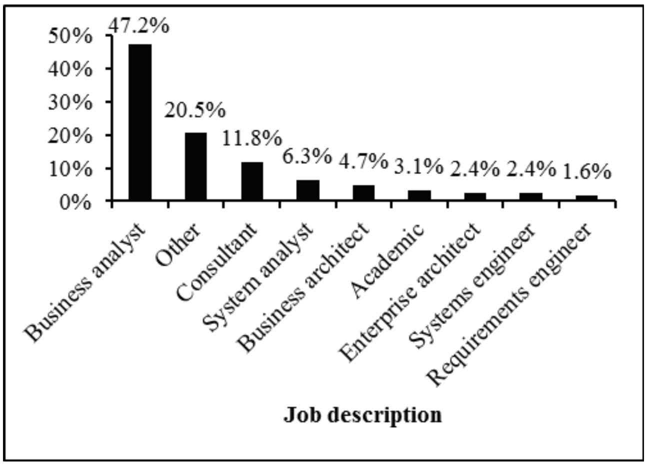

Figure 4: Respondents' job descriptions

The respondents were asked how many years' experience they had as a requirements practitioner. Only 3% of the respondents had less than one year of experience, 19% had between one and three years' experience and 22%

had between four and five years' experience. The majority of respondents were practitioners, with 56% of respondents with 6 years and more of experience.

Focused tertiary programmes and industry-specific certification for requirements engineering are available [53, 72, 73]. However, the practitioners surveyed held very diverse tertiary degrees with no uniform education amongst them as can be seen in Figure 5.

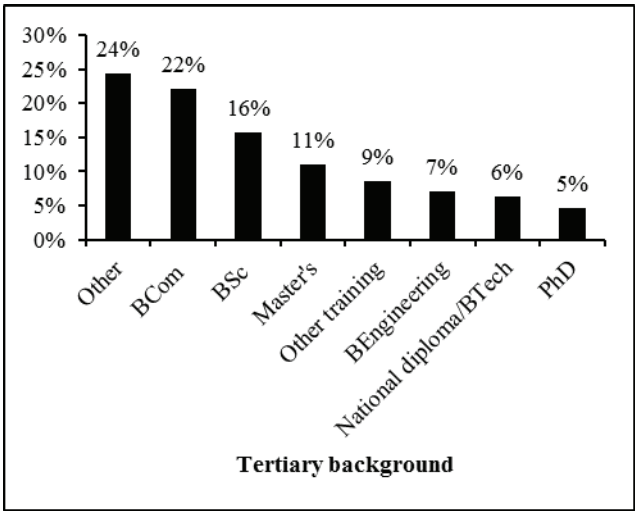

Figure 5: Practitioners' tertiary background

Respondents with BCom or BSc degrees had degrees within the information and communication technology (ICT) industry. Respondents with degrees outside these qualifications are listed as 'Other'. The industry certifications that supported the practitioners' qualifications were very diverse. One respondent was a certified system engineer. Six respondents were certified business analysis professionals. Additionally, five respondents held SAP certifications; one held a PRINCE certification and three respondents held Microsoft certified systems engineer or development certifications.

This concludes the analysis of the respondents. The following section focuses on how the practitioners in the requirements discipline execute the requirements process, including the usage of best practice tools and techniques.

4.2 Requirements engineering process

To describe how practitioners execute the requirements engineering process, data was collected to measure (i) whether any process models are adopted in practice, (ii) the involvement of practitioners during the activities of the requirements engineering process, including the tools and techniques adopted, and lastly, (iii) the quality delivered as an output of the requirements engineering process.

Requirements engineering process models: In 88% of the cases, a formal approach was used as guidance during project implementation versus the 12% of cases where no approach was followed. An analysis of the formal approaches indicates that incremental development was the most popular approach, with 33% of the respondents using it, followed by the prototyping (24%), agile (19%) and waterfall (13%) approaches as summarised in Figure 6.

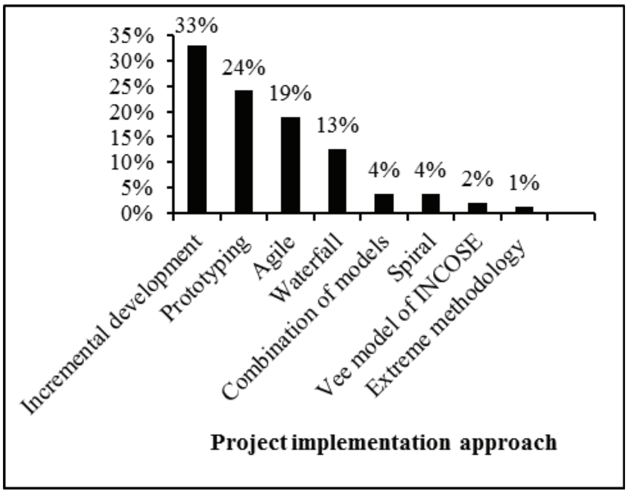

Figure 6: Project implementation approach

Requirements engineering process activities: A study in Australia investigated the barriers experienced by business analysts that prevent them from effective requirements analysis [27]. The original survey questions and data used by Wever and Maiden [27] were shared with the researchers. This was integrated into the questionnaire as a basis to determine the practitioners' involvement during the requirements activities.

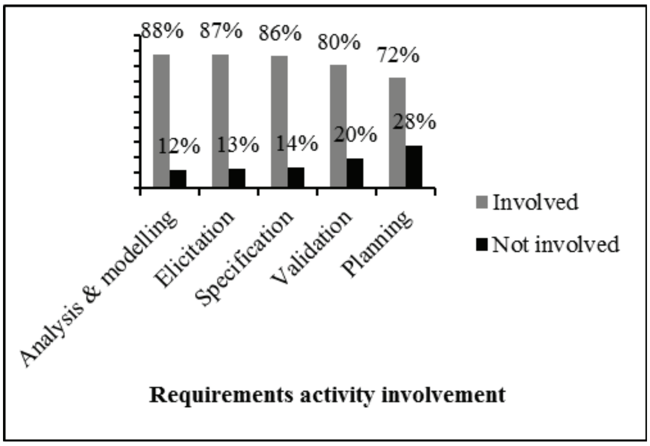

Figure 7: Practitioners' involvement in requirements activities

The practitioners appeared to be very consistently involved in the requirements activities. Most were involved in the analysis and modelling activity but were the least involved in the planning activity. If this is compared with the results of the Australian study by Wever and Maiden [27], no similarities can be identified. The business analysts in Australia reported to be engaged inconsistently across the requirements activities. In that study [27], the practitioners ranged from being the most involved in requirements elicitation (above 80%) to being the least involved in requirements validation (below 60%).

The potential reason for a more consistent involvement across requirements activities in this study compared with the Australian study could be attributed to the fact that the respondents were all experienced practitioners with six years or more experience. The Australian study, on the other hand, reported that the majority of respondents' experience was between one and three years [27].

In the cases where the respondents indicated that they were not involved in the specific requirements activity, an additional question captured the reasons for this non-involvement. Of the 127 respondents, 11 reported that planning was not part of their role. Two respondents mentioned a lack of resources and therefore planning was simply not done. One respondent mentioned that planning was not relevant to the project he was involved in. A further two respondents said: *within my organisation, there is no formal process in place to engage in this activity*, suggesting that planning was not done at all during project implementations. It was also mentioned that in some instances planning was done. However, this was inconsistent and without any continuity. This indicates that planning did not guide the implementation of the requirements during the project at all and was done on an ad hoc basis. In one instance, the planning of the project was done by external vendors. A few respondents also mentioned that they were not given the opportunity to take part in the planning or were not asked to do so.

The reasons provided for the respondents' non-involvement during requirements activities other than planning can be attributed either to the activities not being part of the respondents' role or not relevant to the project.

In addition to the respondents' involvement, the respondents were questioned about the deliverable of each activity and the tools or techniques used to produce the specific deliverable.

Requirements planning: During the planning activity, the requirements practitioner is responsible for creating a requirements management plan which is the key input to the overall project plan [74, 75]. From the results as illustrated in Figure 8, practitioners indicated that the project schedule was a deliverable of the requirements planning activity and not a requirements management plan as suggested by literature. The second important deliverable produced during the planning activity, according to the practitioners surveyed, was a scope of work or problem definition. Thirdly, the actual requirements specifications were mentioned by 10% of respondents as a deliverable, followed by a requirements management plan (9%).

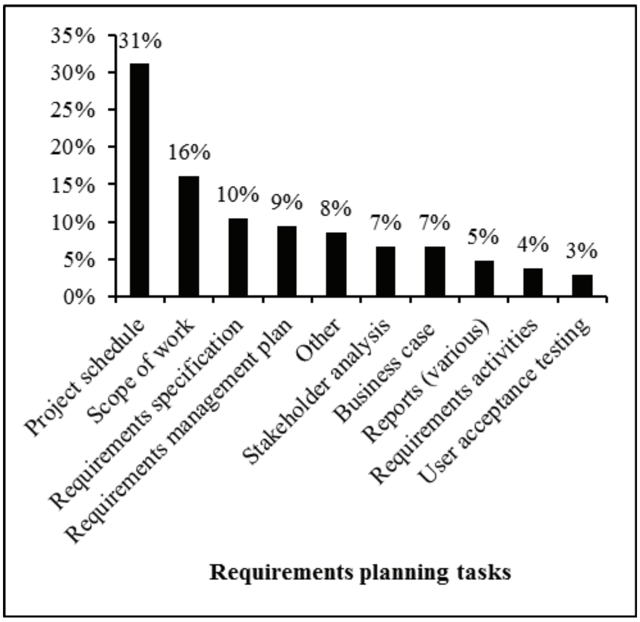

Figure 8: Summary of requirements planning task deliverables

Requirements elicitation: The elicitation activity is the discovery of the knowledge about the problem that should be solved. As time passes by during the problem-solving process, the sources change [76]. During the early stages conversations with colleagues and personal experience were used as illustrated in Figure 9. During the latter stages of the process, textbooks, codes and standards, industry newsletters and conversations with academics were used [77].

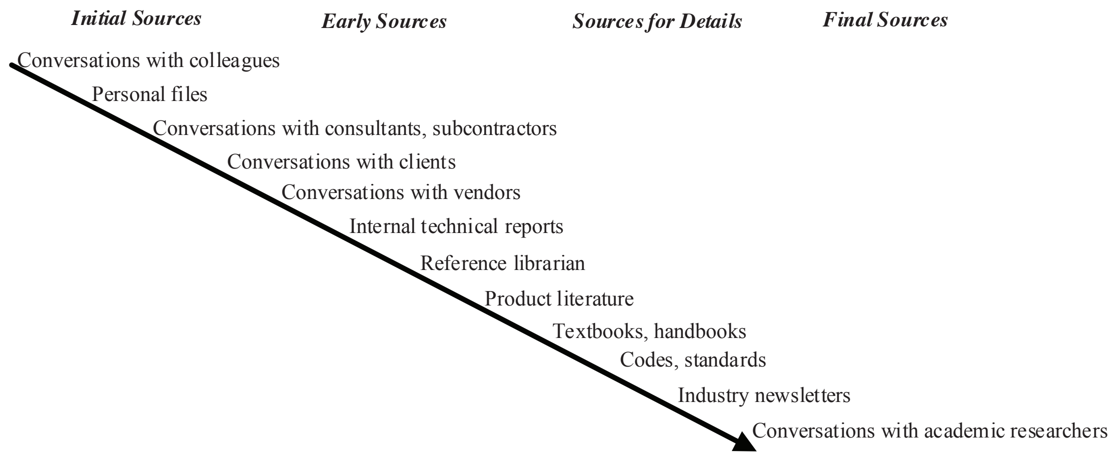

Figure 9: Information-seeking behaviour during the problem-solving process [77]

From the data collected as illustrated in Figure 10, academic, industry and textbook sources were used in a few cases (4%, 5%, and 7%, respectively). The preferred sources which were used by the practitioners were either personal experience or conversations with customers and colleagues, which are classified as initial sources as illustrated in Figure 9. The sources used by the practitioners indicate that the information-seeking behaviour did not follow a typical problem-solving process where the sources changed over time.

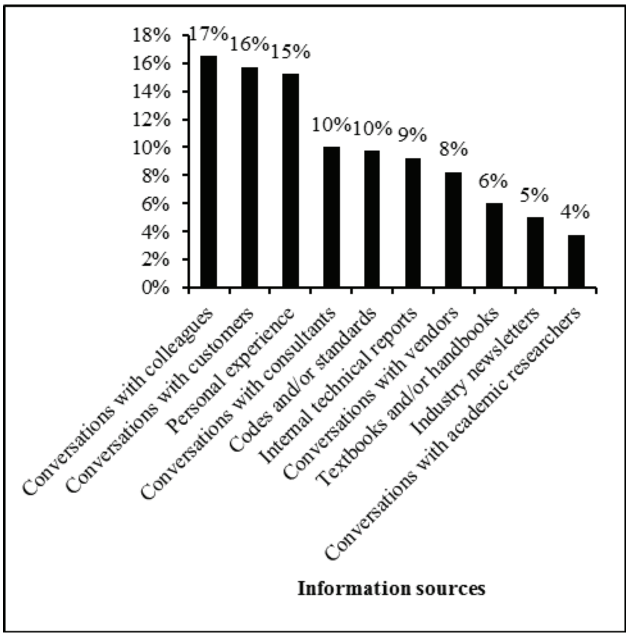

Figure 10: Practitioners' research patterns during elicitation

A list of techniques used to elicit information was derived from literature. The practitioners were requested to rate the usages of each technique on a scale of 'use', 'never use' and 'never heard of'. The results are displayed in Figure 11.

The practitioners utilised interviews, document analysis, groupwork and brainstorming extensively at 98%, 95%, 92% and 90%, respectively. Workshops (86%) and scenarios (81%) were also techniques that were used by the respondents. Prototyping and observation were utilised by 70% and 68%, respectively. Card sorting, ethnography, laddering and repertory grids were used by only a few practitioners.

The respondents preferred traditional techniques such as interviews and brainstorming during requirements elicitation. Literature suggests that the most appropriate combination of techniques must be considered to ensure that all types of knowledge are acquired [47, 78]. A framework for selecting the most effective techniques to access non-tacit, semi-tacit and tacit knowledge has been developed by Maiden and Rugg [47].

The results and comments by the respondents indicate that practitioners surveyed had a set of preferred techniques that were used. They selected techniques based on what technique was known, and not what the most appropriate combination of techniques was to ensure that all types of knowledge were acquired.

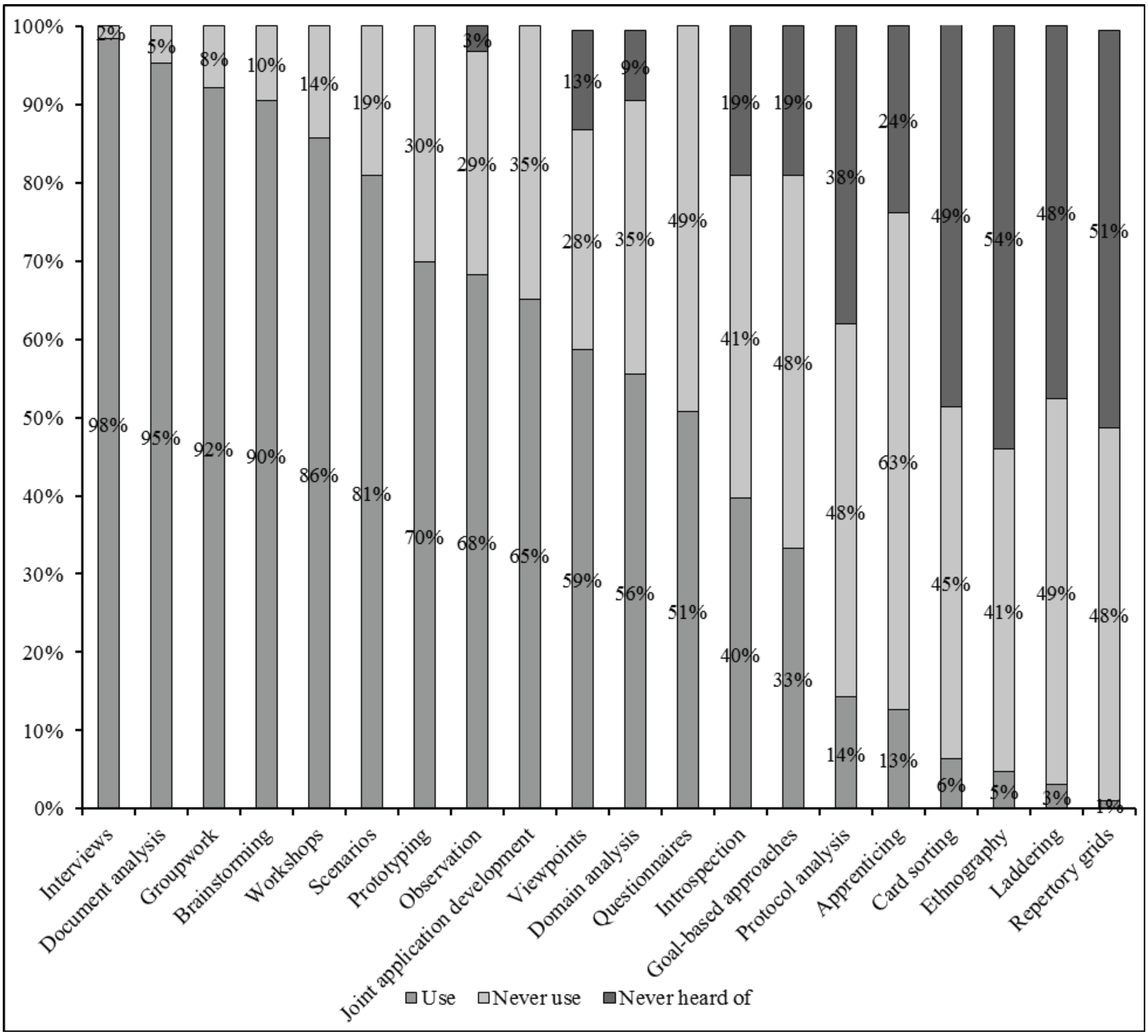

Figure 11: Elicitation techniques usage

Requirements analysis and modelling: The analysis activity analyses all the elicited information and generates a list of potential requirements [48]. The objective of the requirements analysis step is to increase understanding, identify problems and search for inconsistencies in the list of requirements produced [43, 79]. Models are generated to understand the requirements.

A list of techniques used during the analysis and modelling activity was derived from literature. The practitioners were requested to rate the usages of each technique on a scale ‘use’, ‘never use’ and ‘never heard of’.

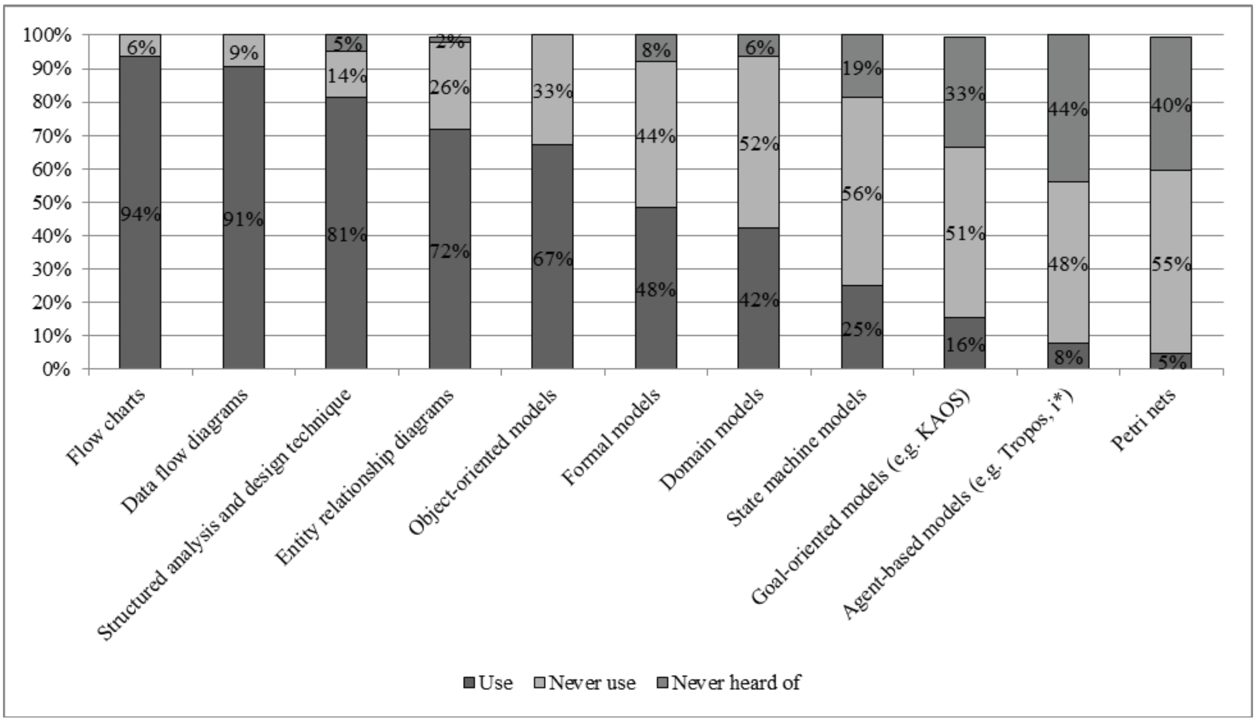

Figure 12: Analysis and modelling techniques

The techniques preferred were flow charts (94%), data flow diagrams (91%), structured analysis (81%) and entity relationship diagrams (72%). Petri nets, agent-based models, goal-oriented models and state machine models were either not in use or not known by most of the respondents.

Requirements specification: The specification is used to facilitate communication and should be complete to ensure that a fit-for-purpose working solution can be produced from the requirements [80]. Of the 127 respondents, 61 indicated how the specifications were generated. In 79% of the cases template guidelines were available to assist the practitioners in generating the specifications.

In 8% of the cases, practitioners used formal notation to present the requirements and 59% used semi-formal notation to present the requirements. The balance (33%) used informal presentation such as natural language to present the requirements. These results were compared with the preferred elicitation techniques of practitioners, which indicates a potential mismatch. The preferred techniques of respondents all deliver outputs in natural language except brainstorming, which will deliver a semi-formal format [46]. However, 59% of the respondents indicated that they produced a specification with a semi-formal presentation. The natural language percentage was expected to be higher, as the elicitation techniques used by practitioners deliver output in natural language. The practitioners stated that they presented their specifications in semi-formal format, but the elicitation techniques that they used did not produce semi-formal notation. It could be that the practitioners generated models from elicited information during the analysis and modelling activity in order to generate a semi-formal notation specification.

Requirements management: The respondents were questioned if a software tool was used to manage the delivered specifications. In total only 12.8% of the respondents used a software tool to develop or manage requirements. Three of the tools mentioned by the respondents used as requirements management tools can actually be classified as requirements management tools, i.e. Blueprint Requirements Center™ 2010, Enterprise Architect and IBM Rational RequisitePro. The other tools mentioned vary from Visio - a modelling tool; SharePoint - a document management tool; System Architecture - a tool used to model business operations and systems. From these results it can be concluded that requirements management tools were not generally used by the practitioners to present or manage requirements.

Requirements quality: The desired output of the requirements engineering process is a set of commonly agreed upon requirements by all stakeholders [39]. The literature prescribes that a requirement should consist of eight characteristics to ensure high quality [51, 81]. As these characteristics are subjective, an ordinal scale was used to measure the quality of the requirements. The scale elements used to determine the quality of the requirements were based on the eight characteristics of a quality specification as per Table 1.

Table 1: Quality scale

Characteristics	Question
Correct	Have all the requirements been validated by the source of the requirement, i.e. typically the stakeholder?
Unambiguous	Was there a single interpretation for each requirement to enable the common understanding by all stakeholders?
Complete	Were all the required requirements present in the specification ensuring a workable solution fit for purpose by the user?
Consistent	Did some requirements conflict with other requirements or with higher level system or business requirements?
Ranked for importance	Were all the requirements prioritised based on importance or in terms of expected changes associated with the requirement?
Verifiable	Was it possible to test each requirement to determine whether it has been properly implemented?
Modifiable	Was a history of changes made to each requirement kept?
Traceable	Was each requirement linked back to its source of origination?

To estimate whether the requirements possessed each quality characteristic, a 7-point frequency Likert-type scale was integrated into the scale with the eight characteristics. The respondents had to rate how frequently the requirements consisted of the eight quality characteristics. The scale used was 1 – Never; 2 - Rarely, in less than 10%; 3 - Occasionally, in about 30%; 4 - Sometimes, in about 50%; 5 - Frequently, in about 70%; 6 - Usually, in about 90%; 7 - Every time.

To simplify the analysis, exploratory factor analysis was used as a data reduction technique to validate whether the eight quality elements could be summarised. The quality of the requirements was summarised separately and displayed for practitioners involved in the requirements activity versus practitioners who were not involved in the activity to see whether this impacted the output of the requirements engineering process. The cross-tabulation in Table 2 indicates a higher percentage quality of requirements when the practitioners were involved. This is the case for each of the activities. The results show a clear pattern of dependency between the quality of requirements and the way the requirements engineering process is executed.

Table 2: Activity involvement by quality of requirements

Requirements activities	Quality				
	Rating 1	Rating 3	Rating 3 to 5	Rating 5 to 7	Total
Planning *Involved* (N=43)	0%	0%	23%	77%	100%
Planning *Not involved* (N=12)	8%	8%	42%	42%	100%
Elicitation *Involved* (N=50)	0%	2%	24%	74%	100%
Elicitation *Not involved* (N=5)	20%	0%	60%	20%	100%
Analysis & Modelling *Involved* (N=54)	2%	2%	26%	70%	100%
Analysis & Modelling *Not involved* (N=1)	0%	0%	100%	0%	100%
Specification *Involved* (N=55)	2%	2%	27%	69%	100%
Specification *Not involved* (N=0)	n/a	n/a	n/a	n/a	n/a
Validation *Involved* (N=49)	2%	2%	18%	78%	100%
Validation *Not involved* (N=6)	0%	0%	100%	0%	100%

1 (Never); 2 (Rarely, less than 10%); 3 (Occasionally, in about 30%); 4 (Sometimes in about 50%); 5 (Frequently in about 70%); 6 (Usually, in about 90%); 7 (Every time)

A Mann-Whitney test was done in each group (involved and not involved) to validate that these two groups did not have the same median. From the test results it was concluded in the case of planning, elicitation and validation that there were statistically significant differences between the groups where there was involvement in the activity: for the planning activity ($U = 124$, $p = 0.005$); for the elicitation activity ($U = 38.5$, $p = 0.009$); for the validation activity ($U = 51$, $p = 0.008$). In the analysis and modelling case the sample available for the not involved group was very small and could be the reason why there was no statistically significant difference between the groups.

These tests confirm that the more the practitioner is involved in the requirements activities, the higher the quality of requirements.

Customer satisfaction: The respondents were asked to indicate from their personal perspective whether the business stakeholders and end-users were satisfied with the implemented solution and to indicate whether the users actually used the system. The results showed an average of 82.46% for the business stakeholders' satisfaction and 81.16% for end-users' satisfaction. These satisfaction levels are high and it could merely be the perception of the practitioners. Correlations were calculated to determine whether there was a relationship between customer satisfaction and usage of the solution. A negative relationship was identified between end-user satisfaction and usage of the solution, with a correlation of -0.288* significant at the 0.05 level.

The following reasons were provided by respondents as to why customers do not use the solution:

- The users do not understand how the technology supports their business processes.
- The users are still using the old solution.
- The users do not use training and user manuals.
- Users are waiting for more requirements to be implemented.
- Development is still in progress.
- Users are forced to use the solution but don't like it (imposed on the industry).

The perception of the practitioners is that customer satisfaction levels are high; however, the relationship with the usage of the solution by stakeholders suggests that there is more information that must be explored. In future research, this relationship needs to be explored directly with the stakeholders as previously suggested.

5. CONCLUSIONS

Real data has been provided regarding the requirements engineering process in industry as a reference point. The researchers would, however, like to identify some important findings:

- Requirements planning: Practitioners do not follow a formal planning activity to consider how the requirements activities should be approached prior to executing the activities.
- Practitioners' information-seeking behaviour: The problem-solving process of the practitioners depends on sources of information which are either personal experience or conversations; their information-seeking behaviour does not change over time.
- Tools and techniques used during activities: The tools and techniques selected by practitioners to be used during activities are based on what is known, and not the most appropriate combination of techniques.
- Requirements management tools: Many requirements management tools are available but these tools are not generally used by practitioners to present or manage requirements.
- The results confirmed that in the cases where the practitioners are involved in the activities, high quality requirements are delivered. This implies a more efficient requirements engineering process as the output of the process delivers high quality.

The paper creates a South African context industry description of how practitioners execute the requirements engineering process. It confirms what is known by practitioners and how they use the knowledge of requirements practice. This knowledge provides adequate data on requirements practice within South Africa for future research. It also includes very specific focus areas for practitioners and managers on how to improve the requirements engineering process without adoption of any new tools or methodologies. The focus areas emerging from the results are practical with small changes in practitioners' behaviour that could have a major impact on the results of the requirements engineering process.
The second part of the survey explored how practitioners behave during the requirements engineering process.
This entails a description of how they gather information about the problem during the requirements process, use the information and share their resulting information. By discovering these interaction patterns, communication can be improved and made more effective.

Follow-up reporting will discuss the results from the second part of the survey. The knowledge of practitioners and how they use the knowledge of requirements practice can be applied to focus future research efforts. The knowledge on the behaviour of practitioner could form the basis of cross-disciplinary research.

6. REFERENCES

[1] S. Robertson and J. Robertson: *Mastering the Requirements Process*, Addison-Wesley, Boston, Second Edition. 2010.

[2] R. Gonzales: "Developing the requirements discipline: Software vs. systems", *IEEE Software,* Vol. 22 No. 2, pp. 59-61, 2005.

[3] K. El Emam and N. H. Madhavji: "A field study of requirements engineering practices in information systems development", *Proceedings of the Second IEEE International Symposium on Requirements Engineering*, pp. 68-80, 1995.

[4] A. Aurum and C. Wohlin: "Requirements Engineering: Setting the Context ", in *Engineering and Managing Software Requirements*, A. Aurum and C. Wohlin, Eds., Berlin Heidelberg: Springer, 2005, pp. 1-15.

[5] A. van Lamsweerde: "Requirements engineering in the year 00: A research perspective", *Proceedings of International Conference on Software Engineering*, New York, pp. 5-19, 2000.

[6] B. Berenbach, D. J. Paulish, J. Kazmeier, and A. Rudorfer: *Software & Systems Requirements Engineering: In Practice*, McGraw Hill, New York. 2009.

[7] S. Viller, J. Bowers, and T. Rodden: "Human factors in requirements engineering:: A survey of human sciences literature relevant to the improvement of dependable systems development processes", *Interacting with Computers,* Vol. 11 No. 6, pp. 665-698, 1999.

[8] F. P. Brooks, Jr.: "No silver bullet; essence and accidents of software engineering", *Computer,* Vol. 20 No. Copyright 1987, IEE, pp. 10-19, 1987.

[9] C. Schwaber: "*The Root of the Problem: Poor Requirements*", Forrester Research, Cambridge, September 2006.

[10] M. I. Kamata and T. Tamai: "How does requirements quality relate to project success or failure?", *15th IEEE International Requirements Engineering Conference*, pp. 69-78, 2007.

[11] K. Ellis: "*Business Analysis Benchmark: The Impact of Business Requirements on the Success of Technology Projects*", IAG Consulting Delaware, 2008.

[12] K. El Emam and A. G. Koru: "A replicated survey of IT software project failures", *IEEE Software,* Vol. 25 No. 5, pp. 84-90, 2008.

[13] R. L. Glass: *Facts and Fallacies of Software Engineering* Addison-Welsey, Boston. 2003.

[14] A. Rodrigues: "*Project Goals, Business Performance, and Risk*", Cutter Consortium, Arlington, 2001.

[15] H. F. Hofmann and F. Lehner: "Requirements engineering as a success factor in software projects", *IEEE Software,* Vol. 18 No. 4, pp. 58-66, 2001.

[16] D. Leffingwell. (1997, 12 May 2011). Calculating your Return on Investment from More Effective Requirements Management. Available: http://www-128.ibm.com/developerworks/rational/library/347.html.

[17] A. L. Lederer and J. Prasad: "Nine management guidelines for better cost estimating", *Communications of the ACM,* Vol. 35 No. 2, pp. 51-59, 1992.

[18] D. J. Reifer: "Profiles of level 5 CMMI organizations", *Crosstalk: The Journal of Defense Software Engineering*, pp. 24-28.

[19] I. F. Hooks and K. A. Farry: *Customer-centered Products Creating Successful Products through Smart Requirements Management*, AMACOM/American Management Association, New York. 2001.

[20] B. W. Boehm: "Verifying and validating software requirements and design specifications", *IEEE Software,* Vol. 1 No. 1, pp. 75-88, 1984.

[21] B. W. Boehm: "Software Engineering", *IEEE Transactions on Computers,* Vol. C-25 No. 12, pp. 1226-1241, 1976.

[22] B. W. Boehm and P. N. Papaccio: "Understanding and controlling software costs", *IEEE Transactions on Software Engineering,* Vol. 14 No. 10, pp. 1462-1477 1988.

[23] C. Jones: "Software change management", *Computer,* Vol. 29 No. 2, pp. 80-82, 1996.

[24] B. H. C. Cheng and J. M. Atlee: "Current and Future Research Directions in Requirements Engineering", in *Design Requirements Engineering: A Ten-Year Perspective*. Vol. 14, K. Lyytinen*, et al.*, Eds., Heidelberg: Springer-Verlag, 2009, pp. 11-43.

[25] D. Zowghi and C. Coulin "Requirements Elicitation: A Survey of Techniques, Approaches and Tools", in *Engineering and Managing Software Requirements*, A. Aurum and C. Wohlin, Eds., Berlin Heidelberg: Springer, 2005, p. 19.

[26] S. Hansen, N. Berente, and K. Lyytinen: "Requirements in the 21st Century: Current Practice and Emerging Trends", in *Design Requirements Engineering: A Ten-Year Perspective*. Vol. 14, K. Lyytinen*, et al.*, Eds., Heidelberg: Springer-Verlag, 2009, pp. 44-87.

[27] A. Wever and N. Maiden: "What are the day-to-day factors that are preventing business analysts from effective business analysis?", *19th IEEE International Requirements Engineering Conference*, pp. 293-298, 2011.

[28] C. J. Neill and P. A. Laplante: "Requirements engineering: The state of the practice", *IEEE Software,* Vol. 20 No. 6, pp. 40-45, 2003.

[29] M. Ciolkowski, O. Laitenberger, and S. Biffl: "Software reviews, the state of the practice", *IEEE Software,* Vol. 20 No. 6, pp. 46-51, 2003.

[30] T. E. Bell and T. A. Thayer: "Software requirements: Are they really a problem?," presented at the Proceedings of the 2nd International Conference on Software Engineering, San Francisco, California, pp. 61-68, 1976.

[31] D. Leffingwell: *Agile Software Requirements Lean Requirements Practices for Teams, Programs, and the Enterprise*, Addison-Wesley Boston. 2011.

[32] B. Boehm: "A view of 20th and 21st century software engineering", *Proceedings of the 28th International Conference on Software Engineering*, New York, pp. 12-29, 2006.

[33] I. Sommerville: *Software Engineering* Pearson Education, Harlow, Seventh Edition. 2004.

[34] I. Sommerville: *Software Engineering*, Addison-Wesley, Harlow, Six Edition. 2001.

[35] M. Dorfman: "Requirements Engineering", in *Software Requirements Engineering*, M. Dorfman and R. H. Thayer, Eds., Los Alamitos, California: IEEE Computer Society Press, 2000, p. 531.

[36] B. W. Boehm: "A spiral model of software development and enhancement", *International Workshop on the Software Process and Software Environments,* Vol. 11 No., pp. 22-42, 27-29 March 1986.

[37] A. van Lamsweerde: *Requirements Engineering from Systems Goals to UML Models to Software Specification*, John Wiley & Sons, Chichester. 2009.

[38] B. Boehm: "Get ready for agile methods, with care", *Computer,* Vol. 35 No. 1, pp. 64-69, 2002.

[39] K. Pohl: "The three dimensions of requirements engineering: A framework and its applications", *Information Systems,* Vol. 19 No. 3, pp. 243-258, 1994.

[40] P. Loucopoulos and V. Karakostas: *System Requirements Engineering*, McGraw-Hill, New York. 1995.

[41] K. Pohl: "Requirement engineering: An overview", in *Encyclopedia of Computer Science and Technology*. Vol. 36, A. Kent and J. G. Williams, Eds., 1996.

[42] K. E. Wiegers: *Software Requirements: Practical Techniques for Gathering and Managing Requirements throughout the Product Development Cycle*, Microsoft Press, Second Edition. 2003.

[43] G. Kotonya and I. Sommerville: *Requirements Engineering Processes and Techniques*, John Wiley & Sons, Chichester. 1998.

[44] L. Macaulay: "Requirements for requirements engineering techniques", *Proceedings of the Second International Conference on Requirements Engineering*, Los Alamitos, pp. 157-64, 1996.

[45] B. Nuseibeh and S. Easterbrook: "Requirements engineering: A roadmap," presented at the Proceedings of the Conference on The Future of Software Engineering, Limerick, pp. 35-46, 2000.

[46] S. Robertson: "Requirements trawling: Techniques for discovering requirements", *International Journal of Human-Computer Studies,* Vol. 55 No. 4, pp. 405-421, 2001.

[47] N. A. M. Maiden and G. Rugg: "ACRE: Selecting methods for requirements acquisition", *Software Engineering Journal,* Vol. 11 No. 3, pp. 183-192, 1996.

[48] A. M. Hickey and A. M. Davis: "A unified model of requirements elicitation", *Journal of Management Information Systems,* Vol. 20 No. 4, pp. 65-84, 2004.

[49] P. Hsia, A. M. Davis, and D. C. Kung: "Status report: Requirements engineering", *IEEE Software,* Vol. 10 No., pp. 75-9, 1993.

[50] S. Robertson and J. Robertson: "*Volere Requirements Specification Template*", Atlantic Systems Guild Limited, 2010.

[51] IEEE, "IEEE Guide for Developing System Requirements Specifications," *IEEE Std 1233, 1998 Edition*, p. i 1998.

[52] IEEE, "IEEE Recommended Practice for Software Requirements Specifications," *IEEE Std 830-1998*, p. i 1998.

[53] IIBA: "*A Guide to the Business Analysis Body of Knowledge (BABOK Guide)*, Toronto Vol. 2. 2009.

[54] P. Berander and A. Andrews: "Requirements Prioritization", in *Engineering and Managing Software Requirements*, A. Aurum and C. Wohlin, Eds., Berlin Heidelberg: Springer, 2005.

[55] IEEE Computer Society: *Guide to the Software Engineering Body of Knowledge (SWEBOK)*, IEEE Computer Society, Los Alamitos. 2004.

[56] The International Council on Systems Engineering: *System Engineering Handbook*, The International Council on Systems Engineering, San Diego Vol. 3.1. 2007.

[57] F. J. Fowler: *Survey Research Methods*, Sage, Thousand Oaks, Fourth Edition. 2009.

[58] L. M. Rea and R. A. Parker: *Designing and Conducting Survey Research - A Comprehensive Guide*, Jossey-Bass, San Francisco. 2005.

[59] D. R. Cooper and P. S. Schindler: *Business Research Methods*, Mc-Graw Hill, Boston, Tenth Edition. 2008.

[60] T. C. Wagenaar: "Survey Design", in *Encyclopedia of Social Measurement* Vol. 3 P-Y, K. Kempf-Leonard, Ed., Oxford: Elsevier Academic Press, 2005, p. 715.

[61] K. Kelly, B. Clark, V. Brown, and J. Sitzia: "Good practice in the conduct and reporting of survey research", *International Journal for Quality in Health Care,* Vol. 15 No. 3, pp. 261-266, 1 May 2003.

[62] K. A. Rasinski: "Surveys", in *Encyclopedia of Social Measurement* Vol. 3 P-Y, K. Kempf-Leonard, Ed., Oxford: Elsevier Academic Press, 2005, p. 733.

[63] R. Czaja and J. Blair. (2005). Designing Surveys *(*Second ed.). Available: http://dx.doi.org/null

[64] R. Sapsford: *Survey Research*, Sage, Thousand Oaks. 2007.

[65] M. Marpsat and N. Razafindratsima: "Survey methods for hard-to-reach populations: Introduction to the special issue", *Methodological Innovations Online,* Vol. 5 No. 2, 2010.

[66] F. Baltar and I. Brunet: "Social research 2.0: Virtual snowball sampling method using Facebook", *Internet Research,* Vol. 22 No. 1, pp. 57-74, 2012.

[67] A. Bryman and E. Bell: *Business Research Methods*, Oxford University Press, Oxford, Third Edition. 2011.

[68] P. Biernacki and D. Waldorf: "Snowball sampling: Problems and techniques of chain referral sampling", *Sociological Methods & Research,* Vol. 10 No. 2, pp. 141-163, 1 November 1981.

[69] B. Paech, T. Koenig, L. Borner, and A. Aurum: "An Analysis of Empirical Requirements Engineering Survey Data", in *Engineering and Managing Software Requirements*, A. Aurum

and C. Wohlin, Eds., Berlin Heidelberg: Springer, 2005, pp. 436-487.

[70] F. Houdek and K. Pohl: "Analyzing requirements engineering processes: A case study", *Proceedings of the 11th International Workshop on Database and Expert Systems Applications*, pp. 983-987, 2000.

[71] C. Quinlan: *Business Research Methods*, South-Western Cengage Learning, Hampshire. 2011.

[72] J. E. W. Holm, M. van der Walt, and P. W. Stoker: "Systems Engineering Training in Engineering Education", *Transforming Engineering Education: Creating Interdisciplinary Skills for Complex Global Environments, IEEE Conference*, pp. 1-14, 2010.

[73] IREB. (2006, 9 June 2012). *International Requirements Engineering Board*. Available: http://www.certified-re.de/en/

[74] B. Carkenord, C. Cartwright, R. Grace, L. Goldsmith, E. Larson, J. Skrabak, and C. Vonk: "Partnering for Project Success Project Manager and Business Analyst Collaboration", *Proceedings of the PMI Global Congress* Washington, DC, 2010.

[75] S. Weese and T. Wagner: *CBAP/CCBA Certified Business Analysis Study Guide*, Wiley. 2011.

[76] C. Tenopir and D. W. King: *Communication Patterns of Engineers*, Wiley, Hoboken. 2004.

[77] D. Veshosky: "Managing innovation information in engineering and construction firms", *Journal of Management in Engineering,* Vol. 14 No. 1, pp. 58-66, 1998.

[78] L. Upchurch, G. Rugg, and B. Kitchenham: "Using card sorts to elicit web page quality attributes", *IEEE Software,* Vol. 18 No. 4, pp. 84-89, 2001.

[79] A. M. Hickey and A. M. Davis: "Requirements elicitation and elicitation technique selection: Model for two knowledge-intensive software development processes", *Proceedings of the 36th Annual Hawaii International Conference on System Sciences, 2003*, p. 10

[80] T. NATURE: "Defining visions in context: Models, processes and tools for requirements engineering", *Information Systems,* Vol. 21 No. 6, pp. 515-547, 1996.

[81] C. Denger and T. Olsson: "Quality Assurance in Requirements Engineering", in *Engineering and Managing Software Requirements*, A. Aurum and C. Wohlin, Eds., Berlin Heidelberg: Springer, 2005, pp. 178-200.