Empirical Validation of the Effectiveness of the Characteristic (Cognitive Load) for Requirement Decision Support System (REDSS)

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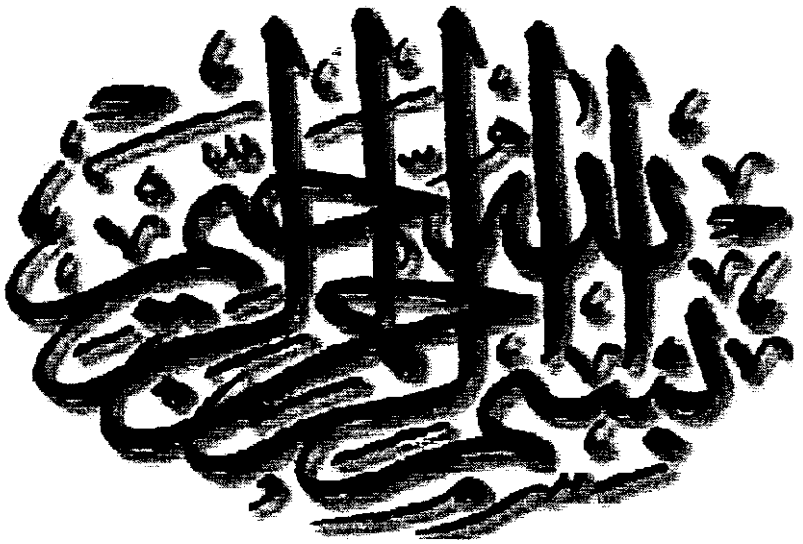

In the name of Allah the most beneficent and merciful.

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Final Approval

It is certified that we have read the project report submitted by **Falak Sher** Registration Number **14-FBAS/MSSE/S10.** It is our judgment that this project is of sufficient standard to warrant its acceptance by the International Islamic University, Islamabad for the Master of Science Degree in Software Engineering.

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Dedicated To

HAZRAT MUHAMMAD (SAW)

& To

My Loving Parent & Family

Who are a source of courage ,honesty and love,

without their prayers it was not possible for me to

complete this research

& To

Precious Friendship

That has made us laugh, held us when we cried

and always, always, be among us

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the Award of the Degree of

MS in Software Engineering

DECLARATION

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Falak Sher (14-FBAS/MSSE/S10)

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Falak Sher (14-FBAS/MSSE/S10)

PROJECT IN BRIEF

Project Title: Empirical Validation of the Effectiveness of the Characteristics (Cognitive Load) for Requirement Engineering Decision Support System (REDSS)

Organization: International Islamic University, Islamabad, Pakistan.

Objective: The main purpose of this research is to empirically validate the characteristic (Cognitive load) which has major impact on the quality of decision making for Requirements Engineering Decision Support System (REDSS).

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ABSTRACT

Decision making is one of the very complex situations in requirement engineering. There are certain factors which affect directly or indirectly the quality of decision making. Certain characteristic and guiding principles also exist and theoretically grounded which can play important role in improving the worth of decision making. But there is a need to imperially improve and evaluate these characteristics and their guiding principles for their effectiveness and prioritization. One of these characteristics is cognitive load which is major cause for effectiveness of quality of decision making in requirement engineering. It can be reduced by following the guiding principles giving detail and overview information about the system during decision making in different phases of requirement engineering. Similarly different techniques also exist in literature which can help in reducing Cognitive Load during decision making process in Requirements Engineering. However, it is required to evaluate the usefulness of these characteristics in term of their effectiveness, valuable in a certain context, and their priority for increase of efficiency.

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Chapter # 1

INTRODUCTION

1. INTRODUCTION

Requirements Engineering (RE) is very critical activity for those who are in the field of research and development in the field of software industry for last many decades. It has been recognized that due to complex nature of the area software engineering it is very difficult to make decision during its different phases. Our ultimate perspective throughout this thesis is to focus on validation aspect of characteristics required for decision making in Requirements Engineering to improve the quality of decision making in RE decision support systems (REDSS)

Imperial validation for such characteristics which influence REDSS should focused on enhancing the decision making capabilities to perform decision making during decision situations in the requirement engineering decision process. Presently, there is a need to go for justification in term of practical implementation of existing guiding principles and characteristics for to facilitate decision making requirement of requirements engineer in the field of requirements engineering for decision support. Moreover there is a need to work on existing requirements engineering tools to validate their existing capabilities in term of support for requirement engineering to augment their decision capabilities in decision support system. It is also required to consider different level where there is a need for support to help decision maker in their decision making process to improve the quality of their decision in the field of requirements engineering and in the field of research. Therefore, we have decided to target the practical aspect of the industry to explore current situation of existing tools and introduction of new direction in the form of prototype to overcome the problems of the industry as well as researcher for decision making for requirements engineering.

1.1 Requirements Engineering (RE)

Requirements engineering (RE) is the "branch of systems engineering concerned with the desired properties and constraints of software-intensive systems, the goals to be achieved in the software's environment, and assumptions about the environment" [2].

The definition of RE provided by Zave et al [1] is: "Requirements engineering is the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behavior, and to their evolution over time and across software families".

Nuseibeh and Easterbrooks [5] define "RE as a series of decisions that lead from recognition of a customer problem to be solved (or a need to be satisfied) to a detailed specification of that problem".

The decision making complexity begins from the inadequate capacity to understand the things related to decision making in particular domain, another thing is time limitation for decision making, and the limitations of our schemas [6][7].

Cognitive load is termed as "construct representing the load that performing a particular task imposes on the cognitive system" [9]. Simply cognitive load can be expressed in term of a mental effort or exertion encountered during decision making. Cognitive load helps in interpreting and processing the information in order to take decisions about a particular action within the specific time frame [4].

1.1.1 Categories or Classes of Requirements

There exist many different categories or classes of requirements but the two major categories are:

- Functional requirements and
- Non-functional requirements

There are three groups which are defined for the storage of non-functional requirements in [10]:

- Organizational requirements
- Product requirements and
- External requirements

There is another categorization of the requirements which is given in [11]:

- Goal based requirements
- Domain based requirements
- Product based requirements
- Design based requirements

1.1.2 Requirements Specification

A requirement specification is defined in two different contexts. Requirements specifications describe the requirement engineering activities in order to specify requirements and these will be easily understandable by the respective stakeholders or it is a document which covers all the all the requirements which provide a thorough description of the functionality of the system i.e. what the system will perform [26]. It may not be treated as a contradiction rather these are two faces of a coin. There is the need to perform or start a particular activity in order to gather the specific requirements.

Requirements specification demands to specify the different categories of the requirements and these requirements must be clearing, easy to comprehendible and unambiguous. The unambiguous requirements will be interpreted by the users incorrectly and inappropriately. The natural or formal language is used to write requirements [34]. For communicative reasons the natural language is used to specify requirements [38]. Formal language is not a common protocol for communication among people rather the natural language is preferred by the people. For requirements validation the natural language is most suitable because it is not specific to any domain or context. The natural language is given preference due to its flexibility over formal

language [38]. There is an issue with the natural language that it is often ambiguous and is not easy to comprehend. Such an ambiguity may result in misinterpretations or delusions [33] [34], and as a result problems occur during the system development life cycle and affect quality in the system.

For development of successful system there is the need to specify clear requirements but ambiguous requirements reduce the chances to get the desired goals. The problem of misunderstanding in requirements specifications will result in quality problem. Some of the most prominent problems associated with requirements are inconsistency, incomplete and the problem of wrong requirements which may result in conflicts [33]. The problem of changes, regarding requirements, is very costly and it will result in confusions among various stakeholders [33].

To specify the requirements at various stages or levels is due to the importance of traceability and the requirements' dependencies at all levels [37]. The decisions to change a particular requirement will also affect the other requirements. The requirements which are the part of an organization are also the part and parcel of a particular project. Same is the case for the requirements which are the part of a project are also the concretization of the requirements of the organization. For proper decision making the decision-maker are in need of an information about relationships among different requirements and information about some of the consequences must be known in order to take particular decision.

1.2 Requirements Engineering Activities

1.2.1 Requirements Engineering - Process

There are different activities in the RE process which increases the knowledge and various information flows. The prominent activities, which are the part of RE process, are requirements elicitation, to analyze the requirements, to negotiate the requirements, to validate the requirements, document the requirements, and manage them properly. The discovery of requirements is performed through requirements' elicitation activity. In requirements analysis the refinement of the raw requirements is performed in order to streamline the development process based on these refined requirements. Different

stakeholders are involved in the requirements engineering process, keep different views and they have different needs towards requirements. So there is the need to negotiate the requirements in order to get the agreed upon conditions or requirement set. In validation the requirements are validated in order to develop a quality system. The documentation of requirements helps in streamlining the future system and in requirements management.

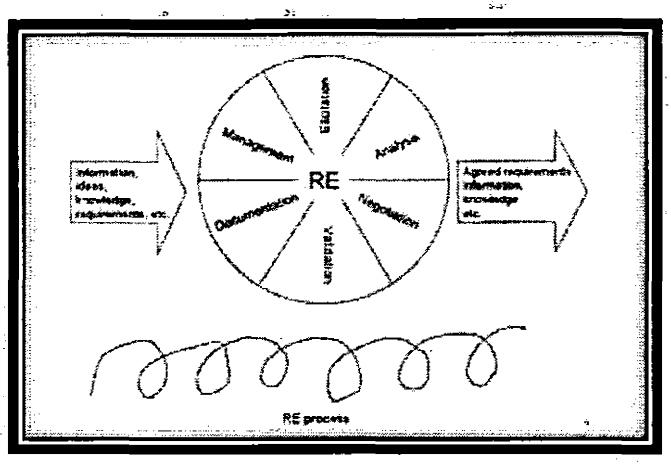


Figure 1, the iterative RE process with its interrelated and interdependent activities

1.2.2 Requirements Elicitation

To produce the system requirements is the core activity of the RE process. The needs of the stakeholders and users are gathered in the requirements elicitation phase and these requirements are communicated with the developers in order to develop a quality system. The requirements are gathered from different sources e.g. these may be opinions of the stakeholders, the existing system and the documentation [33] [36]. Requirements elicitation and data gathering are the same in which the relevant aspects of the data are bundled together. In RE process the "Data gathering" is performed several times in order to get the relevant and complete data set and it is impossible to acquire a complete set of data in one succession of requirements elicitation. The RE process increases the understanding of the data i.e. which data is essential and which data is not essential. Zowghi and Coulin are of the view that the requirements elicitation phase "must allow for communication, prioritization, negotiation, and collaboration with all the relevant stakeholders [36]. It must also provide strong

foundations for the emergence, discovery, and invention of requirements as part of a highly interactive elicitation process."

The requirements elicitation process is comprised of following five activities [36]:

- Understanding the application domain
- Identification of requirements sources
- Stakeholder analysis
- Selection of techniques, approaches, and tools
- Requirements elicitation

1.2.3 Requirements Analysis

In RE process the elicitation and analysis phases are linked or dependent upon each other and they are iterative in nature. Any phase without the other phase is of no importance. The data which is gathered in the elicitation phase is analyzed in order to understand the user and stakeholder's needs. In requirements analysis phase the data analysis is performed. In requirements analysis phase the data is organized in order to make it useful for future system. The analysis phase helps in understanding of the conflicts among requirements and provides awareness about missing data. The two phases i.e. requirements elicitation and requirements analysis are carried out at the same time or may be conducted one by one.

Kotonya and Summerville say that the requirements analysis phase is used to develop a requirements set which is complete and consistent [33]. The requirements, which are established in a data set, must be checked that either they are feasible or not within the defined constraints of time and budget. The requirements specifications document must be properly checked in order to find out the missing information, conflicted information or requirements, ambiguity among requirements and to find out the overlapping of the information [33]. Sutcliffe is of the view that the gathered information helps in understanding the system and then to model the system and the information is required to write the use case scenarios [34]. In requirements analysis the following types of information are gathered i.e. static, dynamic, intentions and contextual. The static

information describes attributes, entities, relationships and different states while the dynamic information describes actions, events, procedures, and tasks. Contextual information is associated with system settings and the intentions describe the intended arguments and goals. The information is used to refine the requirements, to interpret the requirements, to model and design the system. [34].

1.2.4 Requirements Negotiation

The needs or goals of different stakeholders and process of the system engineering are different. The different needs and perspectives have deeper effects on the collected requirements so there is the need of trade-offs in order to remove the necessary conflicts [33] [34] [35]. The conflict resolution is performed in requirements negotiation phase, in requirements negotiation phase the conflicts are resolved through compromises [33]. In RE process the requirements negotiation phase is an iterative activity in which the conflicts are discussed several times. In other activities of the RE process the negotiations are also made e.g. if the stakeholders have to conduct the analysis of a goal together then they will negotiate the importance of the goal which is under process.

In requirements negotiation phase the stakeholders agree on a specific set of the requirements. Sutcliffe describes that an agreement is made regarding design options and trade-offs in order to resolve the conflicts among requirements [34]. The requirements selection helps in prioritizing the requirements. The requirements negotiation phase helps in understanding the causes of the disagreements among various stakeholders [35]. The disagreements among various stakeholders may result in severe threats so special attention is required for them and they must be handled in project management phase.

1.2.5 Requirements Validation

The different meanings of requirements validation phase are described in the literature review. Sutcliffe is of the view that requirements validation phase "involves getting users to understand the implications of a requirements specification and then agree that it accurately reflects their wishes" [34]. There is a contrast among the statements of

Sutcliffe and "Kotonya and Sommerville". Kotonya and Sommerville describe the requirements validation phase that it is "concerned with checking the requirements document for consistency, completeness, and accuracy" [33]. Kotonya and Sommerville writes about validation phase that "the aim of requirements validation is to 'validate' the requirements, i.e. check the requirements to certify that they represent an acceptable description of the system which is to be implemented" [33]. Sutcliffe is focusing on the users and focusing the issue that how the users will be able to understand the consequences or costs of the intended requirements. The users' perspective is also important but it is not sufficient. Some of the important stakeholders in requirements validation phase are customers, project sponsors and government agencies. In user requirements validation phase the major problem is to find out real users and their availability is not possible readily. Their availability is based on the type of application. The user availability is only possible in development of in-house systems instead of the market driven systems.

1.2.6 Requirements Documentation

Huge resources are required to invest in the requirement engineering process in or to get a sufficient or lot of information. The documentation of the gathered information is required which is used by the stakeholders for their intended purposes. Documentation is also termed as an activity or artifact. The requirements documentation phase in the RE process is a continuous process in order to save the important information which is required to understand the context of a particular system or system under development.

The requirements documents are saved and then accessed using media like hard copy on paper or a soft copy on computer. The media may be used in a combination i.e. the information is stored in a database and then is retrieved in the form of reports on the paper or document. Hoffmann et al. describe that "the days of paperless development are still far away, especially in fields where interaction with suppliers is important. [29]"

Requirements specification document is an important document but there are some other documents which are enlisted by Eriksson as [28]:

- "Preliminary study documents "
- "Vision documents"
- "Use cases"
- "Supplementary specifications"
- "Change requests"
- "Sequence diagrams"
- "Function specifications"
- "Screen layout"
- "Design specifications"
- "Graphical user interface standards"
- "Component specifications"

1.2.7 Requirements Management

Requirements management and requirements change management activities are the important parts of RE process. The requirements change continuously, so the changes must be handled in an efficient and effective way. The other significant areas in the RE process are requirements management tools, requirements prioritization, impact analysis, quality assurance, requirements traceability and requirements dependencies [44]. Figure 2 shows the summary of the important requirement management areas.

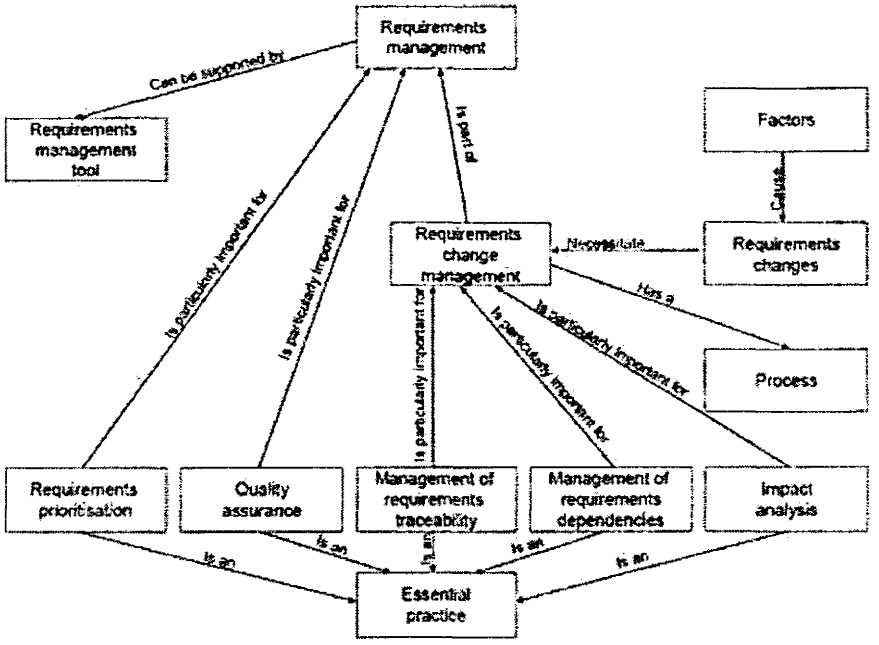


Figure 2 Requirements management and related aspects

1.3 Requirement Engineering Tools

There are different complicated and significant activities which are involved in RE process. In order to perform the RE process successfully the requirements engineer must be professional and skilled. The skills and professionalism is not sufficient when the project or system size increases. The assistance is required to the requirement engineers in order to perform the different RE tasks in a professional way. RE tools provide a partial assistance to requirements engineer in order to carry out the tasks. Matuleviėius defines the RE tools as "software tools that provide automated assistance during the RE process and support the RE activities" [25]. The RE tools are also called as the requirements management tools [27] [29] [31] [32].

The support is also needed in other RE activities and tasks like in generation of innovative ideas for next generation systems, providing solutions to requirements conflicts and errors and to propagate the useful requirements information. So in this research the term RE tool is commonly used instead of using the term requirements management tools. Figure 3 depicts the different types of RE tools as described by INCOSE [32].

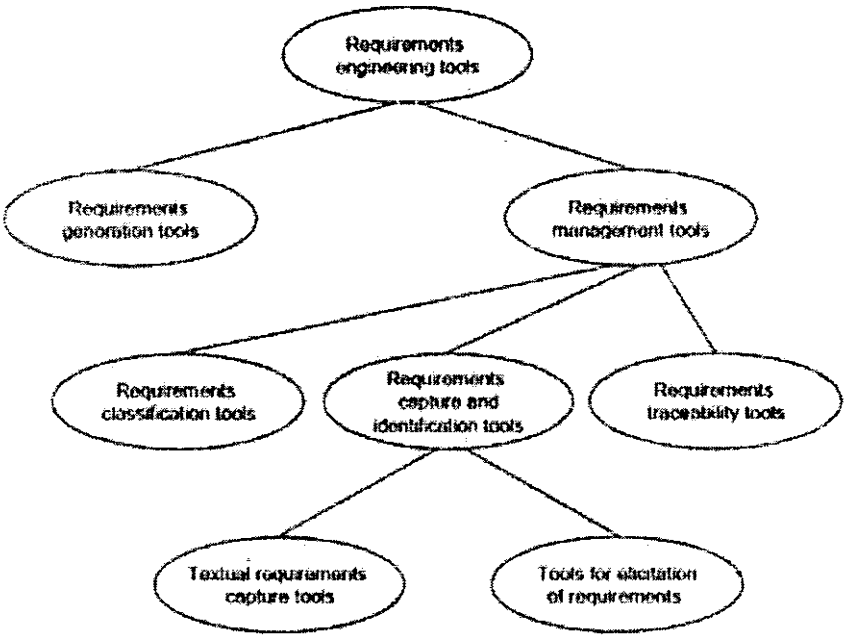


Figure 3 Types of RE Tools

In order to produce the low level requirements in a systematic way the tools different RE tools are used. The low level requirements are generated based on the constraints defined for design and also due to the simulations of the system [32]. The INCOSE is not describing that either the low level requirements are generated automatically or manually. The requirements generation is possible in both ways to some extent but the human involvement is also vital. The description given by INCOSE about a requirements classification tool as it helps in requirements classification which facilitates in time scheduling and to track the activities associated with requirements analysis [32]. An RE capture tool uses many different text sources in order to compile or gather the required information. RE tools are also helpful in finding out the relationships among different documents. The unnecessary information is separated from the set of requirements with the help of a requirements identification tool. The

links between system requirements and artifacts like requirement changes, models and information sources are managed with the help of a requirements traceability tool [32]. The categorization of the tools which is shown in the figure 3 shows that the current RE tools are not supporting all different aspects of RE process. Currently there is not the existence of any tool which may help in requirements negotiation and validation. Perhaps there may be the existence of such RE tools, but are not categorized here and it shows there are some loopholes which may pave the way for improvements in RE process.

The categorization of RE tools given by INCOSE is problematic in the sense that the functionality of the RE tools is described in a broader perspective but the tool may be divided into separate several categories [25]. So the classification becomes very complex and the overall value of classification is decreased. The categroisation of RE tools given by INCOSE is also problematic in the sense that in the market several RE tools are available in the form of COTS [30] [31]. So, the functionality of the tool is specific i.e. the tool will provide the specific RE functionality for which it is purchased by the purchaser. Thus, the categorization may vary depending upon the intended functionality of the RE tool.

Currently the integration of RE tools is going to be held with the development process tools, and this integration is helpful in managing the life cycle of the product under development [2]. A requirement database is the part of the many available RE tools and this database helps in storing the requirements or information and all other documents which are related to these requirements. The database is helpful to overview, organize and find the intended requirements [28]. Eriksson says that the requirements, test cases and errors are managed by different RE tools. There are Re tools which support prioritisation and requirements checking [28]. The RE tools don't cover all of the aspects of the RE process.

In literature several suggestions are given in order to improve the RE tools and different characteristics are provided [2] [28] [29] [32] [27] [26]. The suggestion which are given regarding RE tools are that they "must support base-lining and configuration management, be user-friendly, support standard systems modeling techniques and

notations, allow the user to freely define a requirements management model, improve facilities for the geographically distributed collaborative work, and inter-tool communications" [26][27]. So there are many different relevant suggestions in order to improve the RE tools. The suggestions, characteristics and requirements which are given in the literature are not related to the RE decision support system.

There are certain advantages of the RE tools as compared to the other tools like MS Word, MS Excel, and Visio. It is depicted in a case study that a document prepared with the help of a RE tool is of high quality than the document which is prepared with an office or modeling tool [26]. Eriksson describes that the functionality of RE tools is dedicated and helps in managing the requirements efficiently. A relationship overview between requirements is also possible [28]. Requirements can be checked and approved using RE tools. Using MS Office and modeling tools the requirements cannot be checked and approved effectively or smoothly. [28]. RE tools help in achieving the goals which are associated with requirements management [29]. RE tools also help in writing the requirements uniformly [28]. The complexity of the RE activities is also overcome using RE tools [31]. The management of the complexity by RE tool is very helpful for professionals [30]. Mostly in the industry the RE practices are carried out in MS Office and different modeling tools and there is no adoption of RE tools [25].

There are different reasons due to which the industry professionals are not using RE tools in order to streamline the RE process. One of the reasons is that it is not possible that the RE tools are suitable for all industries and projects and so they cannot be helped from requirements engineering tools. Eriksson and Hoffmann et al. say that, for proper utilization of RE tools there must be a mature work process in a company [28] [29]. The importance of RE tools increases with the factors: a) when requirements exceed in number i.e.100-150, b) when in RE work there is the involvement of several people, c) if there is an increase in risks, projects, budget and participants, d) when frequent reuse of requirements is in the way, as well as e) if there is the involvement of several organizations in order to conduct a project [28] [29]. The organizations where the projects are small, where there are few project requirements, or in case of single organizations then there will be huge burden management due to usage of RE tool.

Most of the organizations are not in a practice of using RE tools due to the shortcomings and the challenges faced and managed by the professionals. The interface provided by most of the RE tools is not user friendly so the engineers are not giving a positive feedback about the use of RE tools [29]. Hoffmann et al., describe that during traceability maintenance the cost goes beyond the benefits [29]. It is also difficult to integrate all the RE tools to work together which are purchased from different suppliers [28]. RE process is highly required for software engineering, so the integration of RE tools is essential for smooth working. In RE tools there is no consideration of social aspects of the software development process [27]. The RE tools are not providing any support for distributed and multidisciplinary software team [26]. There is no value or benefit of an RE tool and the use of these tools in the long run are also very limited [25].

The RE process is comprised of decisions situations and the activities which are part of the decision making process. The decisions and activities are vital for system development and for the software engineering process. The skills and abilities of an RE engineer can be polished if the RE tool provides proper decision making support. So an important category of a RE tool is the RE decision support system (REDSS). REDSS is currently not supported by existing RE tools and serves as a notion for a new RE tool. REDSS is a term which is used to describe a tool which supports decision making. There is the possibility that a tool may be developed which support the features of decision making. There is the dire need of such RE tools which provide the REDSS features in order to streamline the whole requirements engineering process.

Currently there is not the availability of the characteristics of an REDSS and there is no description of the requirements that should be included in it. If there will be availability of such information then it would be possible to develop a robust sort of RE decision support system and to carry out research in the domain of REDSS.

Chapter # 2

LITERATURE SURVEY

2.1 RE Decision-Making and RE Decision Support – Current Research

The research in RE decision making and decision support is in its initial stages [22] and a very little research is conducted in this field. Ngo-The and Ruhe presented the RE problems in the following perspectives i.e. a requirement-centric perspective and an activity-centric perspective. The requirement-centric perspective is associated with the standpoint of the software researchers and they have a concern with the contexts which are in relation through the requirements. Moreover in requirement-centric perception the problems are related with the requirements. The activity centric perspective is associated with the researchers of decision making theory and they apply this theory in RE domain. They find the problems in software engineering and RE processes. There is a difference in the focus and importance of the two perspectives and they are not same [22]. The research is focusing on activity-centric perspective and primarily on activities of decision making and the problems which software engineer face during RE.

The major problem is to recognize the RE decision making area. RE decision making is only possible if the professionals will have enough knowledge about the domain. So there is the need of a research which must be empirical and theoretical. [22]. in order to get knowledge and to run a research the decision making models and theories are executed. Such a way helps in understanding of the very nature of the decision making activities in RE [23].

A research outline is taken from two different sources one is [22], and the other is [18]). It is required to work on:

- Execute empirical studies for requirements decision making in very comprehensive way
- Explore and consider the factors that affect quality of decision making in our local industry.
- Perform empirical studies of cognitive load as one of the major as major factor that affect quality of decision making in requirements engineering decision support system.
- Perform empirical studies of factors that increase cognitive load during decision making
- Identify the use of RE tools in software Industry
- Identify the impact of use of RE Tools in software industry
- Perform empirical validation of guiding principal providing detail and general overview for reduction of cognitive load
- Perform empirical validation of the improved effect of the guiding principles as a support in the form of RE Tools for decision making to improve quality of decision making
- Identify the availability of standards and implementation of policies as a part of procedures in the industry
- Identify the current tools for requirements management in the industry and their impact on current quality of decision making in the industry

2.2 Requirements Engineering as Decision-Making

Requirements are actually the verbal form of decisions which are related to the functional and nonfunctional attributes of a system. So the requirements are called as the decisions and the whole RE process is called as the decision making process [12] [24].

Requirements engineers are the decision-makers. The decision making is a very complex phenomenon in RE. In decision making many problems are faced by the decision makers during the RE and development process. RE decision support is vital in order to make an RE decision making process more effective and efficient.

2.2.1 RE Comprises Decisions

Evans et al., describe the decision making process as "for the engineering of computer-based systems, the term [and the associated process] of 'requirements' might well be replaced with the term 'decisions' and a decision process" [12]. Decisions regarding functionality and quality of a system, under development, by Stakeholders are described in the form of requirements. There are some other problems associated with the RE process like staffing, planning and organizing. The RE process will fail if the decisions or requirements will not be strong [18]. If the decision making process in RE is properly addressed then it will be possible to engineer the system in a successful way [12]. Only those companies will be successful in future that will use an integration of requirements management, decision making and future planning processes [22]. These successful companies will use "their intellectual capital generated by the decision-making process and would link this process to the essential supporting information" [22].

In RE process the decision making is a continuous activity [12]. A comparison of RE process model [21] and decision process model [16] is presented by Aurum and Wohlin, and it is claimed that there are many similarities between the two. The model presented by Mintzberg et al., help in identification of decisions at micro level [16]. The micro decisions are related to the decision-makers and in it they have to make different decisions. The managerial activities of an organization come in the domain of macro decisions. Both types of decision makings i.e. micro and macro are dependent

upon each other. Micro and micro decisions are the part of RE [12]. In a particular organization the macro decisions are concerned with three levels i.e. strategic planning, operational and management controls [20]. In strategic planning, in RE process, the organizational concerns are taken into account e.g. the requirements must be consistent with the business objectives or goals. The management control or tactical decision making is concerned with the projects e.g. the HR planning process in an organization. The operational control is related with the quality decisions, to classify the requirements, realization of the issues and requirements' properties [12] [18]. Some of the RE decisions consist of the following [12] [19]:

- Selection of functional and non-functional requirements within specified time and budget.
- Requirements organization
- Requirements classification
- Requirements importance
- Stakeholders identification
- Requirements prioritization
- Dependencies among requirements

The decision making in these cases is not simple and decision makers face several problems in making decision in the whole RE process.

2.2.2 Problems of Decision-Making in RE

The decision making in RE process is very complex and it demands too much knowledge intensive practices but there are certain cognitive load limitations which decision makers face [12]. RE decision makers also several other hurdles during RE process and they have to see all these hurdles. Orasanu's and Connolly's presented a list of eight factors and these factors help in characterization of decision making in RE process to structure problems in the decision-making process[40]. The eight factors are listed below.

a) Ill structured problems,

b) Uncertain, dynamic environments,

c) Shifting, ill-defined, or competing goals or values,

d) Action and feedback loops,

e) Time stress,

f) High stakes,

g) Multiple players, and

h) Organizational goals and norms.

2.3 Decision-making and Decision Support System

2.3.1 Definition of Decision

The word decision is used commonly in daily life. Too much literature is available on decision making by people, how the decisions are taken, the ultimate results of these decisions etc. Still there is no clear definition of the word decision. For this the reason may that everyone is well aware with the term decision. However, the interpretation of the term is different by different people and it is a great risk. There are two definitions of the word decision i.e. a decision is a a) "specific commitment to action" [16] or a "reasoned choice among alternatives" [17]. The two definitions of term decision are focusing the different aspects. A decision is also considered as a choice, in which alternatives are evaluated [17]. So in decision making process there is the involvement of two steps. It is considered that many different steps are involved in decision making and the decisions are considered as the last part of the whole process and it is somewhat strange. Mintzberg et al. take the decisions as a result of consequence, so it means an action will always result in a result or consequence. [16]. A decision is considered as a consequence of a decision making process and no action will be associated with it. The major concepts of the research are shown in the figure:

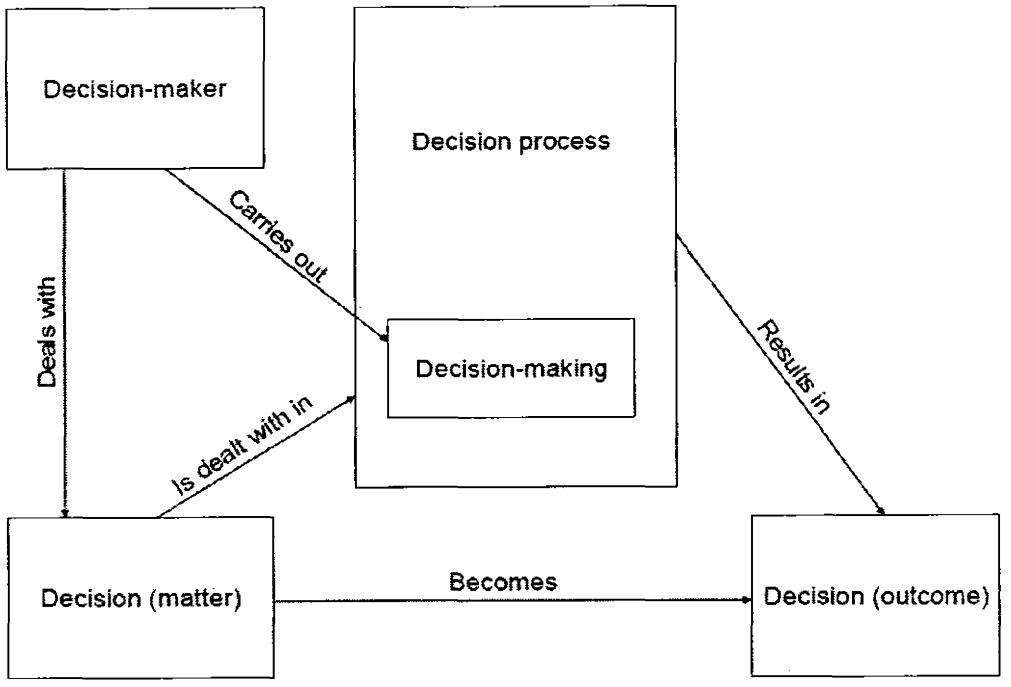


Figure 4: result of a decision process

- There are two meanings of a decision i.e. The decision matter and outcome. The decision matter is handled in the process of decision making. When there will be a choice then the matter turns into an outcome. The decision outcome is an alternative which is taken into account for a given action.
- In Decision-making the decision makers take different decisions and it is a mental or physical state of a decision maker.
- The decision making is carried out by a person called **decision-maker.** The decision making is carried out individually or in multitudes.
- In **decision making process** there is the involvement of different related phases. Different decision making activities are included in these phases.

2.3.2 Types, Characteristics of Decision Support System (DSS)

According to Turban: "A DSS is an interactive, flexible, and adaptable CBIS [Computer-Based Information System] that utilizes decision rules, models, and model bases coupled with a comprehensive database and the decision maker's own insights,

leading to specific, implementable decisions in solving problems that would not be amenable to management science optimisation models per se. Thus, a DSS supports complex decision making and increases its effectiveness [38]."

There are many ways to define the concept of decision support system (DSS). The DSS is a "computer-based information system" that supports organization, individuals as well as group of decision-makers. The decision makers take decisions effectively in order to cope with the problems which are structured or unstructured. The DSS supports series of decision activities performed during decision making process. Similarly application of DSS range many domain of daily life. There is the involvement of DSSs at all levels in an organization i.e. strategic planning, management and operational controls and DSSs provide support to decision makers in the decisions which are volatile in their nature.

The DSS categories given by Power are [8]:

- "Data-driven DSS"
- "Model-driven DSS"
- "Knowledge-driven DSS"
- "Document-driven DSS"
- "Communication-driven and group DSS."

2.3.3 Benefits and Limitation of DSS

The benefits which are associated with the DSS are [15] [8]:

- DSS improves the productivity at individual level
- DSS improves the decision quality and problem solving
- DSS facilitates the communication among stakeholders
- DSS improves the skills of the decision-makers
- DSS increases the organizational control

The limitations listed by Marakas and Power are [14] [8]:

- DSS does not provide human decision making features like imagination, creativity, etc.
- There are the limitations of data, procedures, techniques, models and knowledge stored in a DSS.

- The DSS interfaces are not robust in terms of interaction between users. There is less support of natural language.
- The DSSs are not generic in nature and their scope is narrow.
- A DSS requires its integration with a decision making process.
- The DSS can only be useful if there will be integration of thought and analysis in the offline mode.
- Managers do not accept the involvement of behavioral engineering in their decisions and they consider it as a disturbance in decision making.

2.4 Defining Cognitive Load

Cognitive load is a "mental energy" level which is needed in order to process some provided information [9]. Cognitive load is a sort of force in terms of mental activities which is imposed on memory during decision making in a given time frame. Working memory is the stage of memory where information is stored for a short period prior to forget it or to transfer it to long term memory which is a relatively permanent memory. The cognitive load is experienced due to the working memory limitations. In this section there is the description of different types of cognitive loads which are faced during working memory.

Cognitive load may also be descried as a "construct representing the load that performing a particular task imposes on the cognitive system" [9]. Cognitive load may also be termed as mental exertion. During cognitive load an information is processed and interpreted in a given time slot for a particular action [4]. Human beings possess a very limited capacity of information processing and this capacity is utilized for challenging tasks or jobs [13].

2.4.1 Types of Cognitive Load

The different types of cognitive load are as under: [9]

- Intrinsic Cognitive Load refers to the inherent difficulty of the content.
- Extraneous Cognitive load refers to the load imposed by the instruction design
- Germane cognitive load refers to the degree of effort involved in processing

- Working Memory is used to process information and create schemas in the long terms
- Schemas – learning will only occur if a connection is made to a schematic structure in the long term memory.

2.4.2 Cognitive Load and Decision Support System

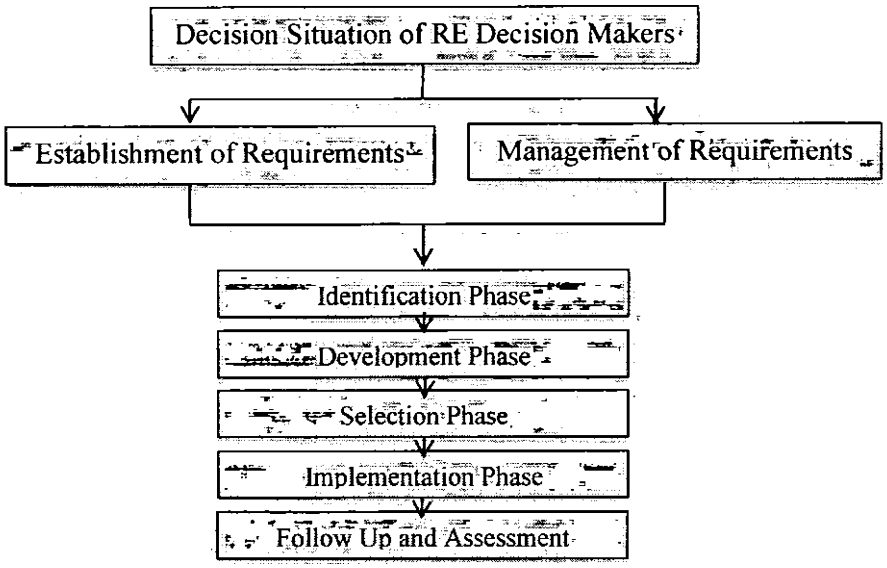
There are three hurdles in which the cognitive load is faced i.e. [44]

- Lack of general overview
- Lack of understanding
- High memory load

2.4.3 Measuring Cognitive Load

	Indirect	Direct
Subjective	• Perception of invested mental effort. • Post treatment questionnaires to report the amount of mental effort (not related to cognitive load).	• Rating of difficulty of material (relates directly to the cognitive load imposed).
Objective	• Analyse performance outcomes measures. • Analysis of behavioural patterns. • Physiological measures such as heart rate and pupil dilation.	• Neuro-imaging techniques that measures brain activity (not inclusive of the complete cognitive process). • Dual task paradigm - Secondary task is added to induce the memory load. Performance in primary task is measured. - Use secondary task to measure memory load. Performance in secondary task is measured.

2.5 Decision Situation Of Re Decision-Makers



The first step towards decision process is the establishment of requirements which is mainly focusing on how to collect requirement, structured and documenting requirements using existing requirement management tools. Moreover it is also compulsory to discuss requirements with the stakeholder for negotiation.[41][42]

In the identification phase of requirements engineering RE decision makers have to go with decision recognition routines and perform many decision related activities. The basic purpose of all this exercise is to achieve the quality of decision making during requirement engineering decision making. [41][42]. this phase also target to distinguish between customer requirements and system requirements. Find out any confusion in system requirements by interacting with customers (stakeholders) to cover system and subsystem level requirements. Moreover there are activities which belongs to process are also considered at this stage, which includes general view of the needs and problems being faced during development process. Decision communications activities are also measured at this step.

During development phase, RE decision makers perform comparison between new requirements and the existing requirements [43]. In this phase customized requirements of stakeholder are fulfilled and existing software are tailored according to user requirements [16]. The selection phase refers to three different styles which includes

analysis where alternatives are evaluated, bargaining deals with the selection of choices with different goals by several decision makers and individual contributes by making their decisions. In implementation phase multiple decisions related activities are performed which cover design specifications, setting requirements documents, communicating decisions etc. similarly in the follow up and assessment phase, the main focused is kept on identification of new problems, verification of requirements, validation of requirements through group meetings and test specifications.

The second part of decision situations is management of requirements that is itself highly iterative process and every decision activity can precedes any possibility and path.

2.6 Factors That Affect the RE Decision-Makers

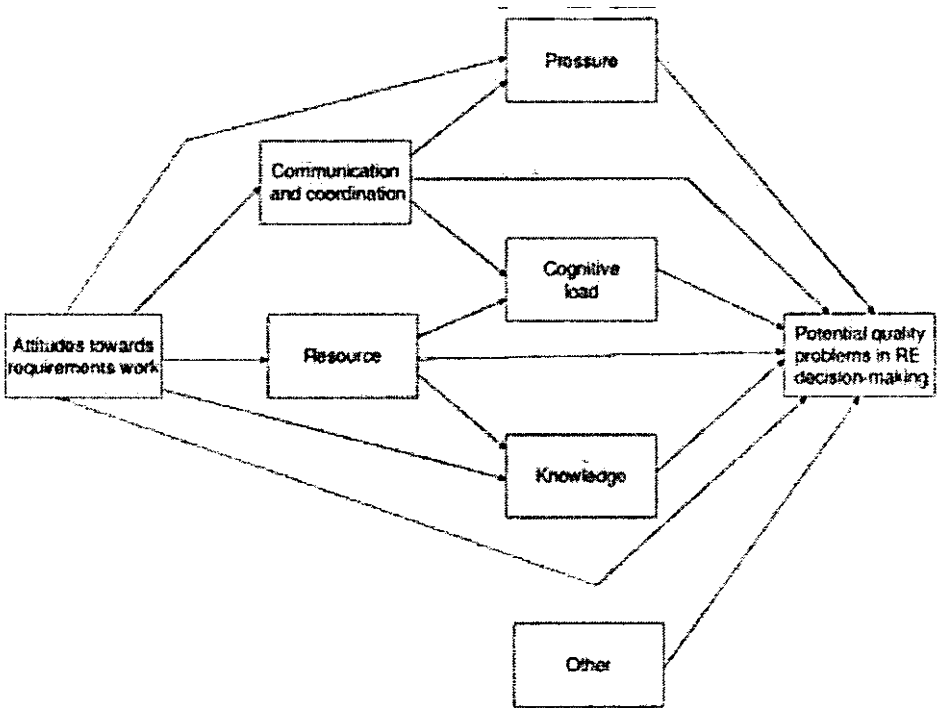


Figure 5. Factors that affect the decision-making of requirements engineers in requirements decision support system [41]

Chapter # 3

PROBLEM STATEMENT

PROBLEM STATEMENT

Requirements engineering (RE) is the "branch of systems engineering concerned with the desired properties and constraints of software-intensive systems, the goals to be achieved in the software's environment, and assumptions about the environment" [2]. The most important part of requirements engineering is to understand the requirements of the domain for which solutions are being developed. Furthermore it is also matter of concern that develops such a system that should meet the needs of the stakeholders. If someone don't know what to develop than he cannot develop or meet the requirements in the right way

Requirements help in communication of decisions related to the favorite functionality and potentials features of a system. Therefore requirements are considered as decisions and requirements engineering process as decision making process [12] [24]. All these decisions administrate the development process and the nature of output. In case of incomplete or inappropriate decisions are made, this result will adversely affect both the development process and the system. Requirements Engineer is an individual who is responsible to carry out and regulate RE decision-making activities.

In nature RE decision-making is difficult and of vibrant process for the quality of the developed system. Therefore, RE decision process and role of RE decision maker can play their role to the usefulness and effectiveness of RE decision-making.

Making decision is the core element of requirements engineering decision making which is performed throughout the development process. [33] [19]. Moreover the requirement engineering process is considered as decision making process from its

inception till its completion. [12] [18].In the whole decision making process it is required to have good understanding and knowledge of decision making domain. Moreover the cognition limitations of requirements engineering decision makers have significant impact on the quality of decision making. [12]. Similarly, RE decision-makers face lot of difficulties those are mostly inherited problems of decision making in natural settings. [40]. There are many factors which affect the quality of decision making in requirements engineering decision making which includes lack of resources, high cognitive load, uneven pressure of work. All these deficiencies should be addressed to improve decision making quality in decision making process. [45].

Till yet no significant contribution is made by the research community in this area to handle issue related to decision making related activities. [22]. The most important issue is to highlight the nature of problem in decision making process, which aspects need to be targeted to help RE decision-makers, identification of decision-making activities, and identification of decision processes as part of decision process. Understanding of the decision related areas may help to attain the quality in RE decision-making process. Therefore it is required to go for theoretical and empirical research in the field of requirements decision making decision support system [22]. The starting point of our research work is decision support theories and models of decision related process. This has helped us to get into more detail in the related domain [11] [18

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For our research process developing support for RE decision-making is an area of concern. Ngo-The and Ruhe [22] supported that RE decision support should not make every effort for optimization. Decision situations may vary from situations to situation

depending on the nature of the problem. There are situation where it is not possible to have optimal solution just because of feasibility.

Following is the detail of our research.

- Empirical validation to limitations and proposed benefits for factors effecting cognitive load and is potential claimed benefits after implementing the proposed factors is missing in the literature and thus there is a need to fill this gap between theory and proposed practice.
- Validation of claims made by various authors in their research and PhD dissertations regarding relationship decision support and cognitive load.
    - The same authors have also proposed that their claims are based on observation and expert judgment. Empirical validation is required for effectiveness of these factors on the quality of decision making in industry projects.
    - This thesis is an effort to collect data and perform its statistical analysis for empirical validation.

3.1 Research Question:

- Do the following principles cover all aspect of cognitive load in decision making in Requirements Engineering?
    - Cognitive load could be reduced by pressing presenting both overview and details
    - Cognitive load could be reduced by providing memory aid
- Does reduction of cognition load (empirical validation) improves quality of decision making in Requirements Engineering?

Chapter # 4

Methodology

Research Activity Flow

Following is the flow of research process which is followed to complete whole work.

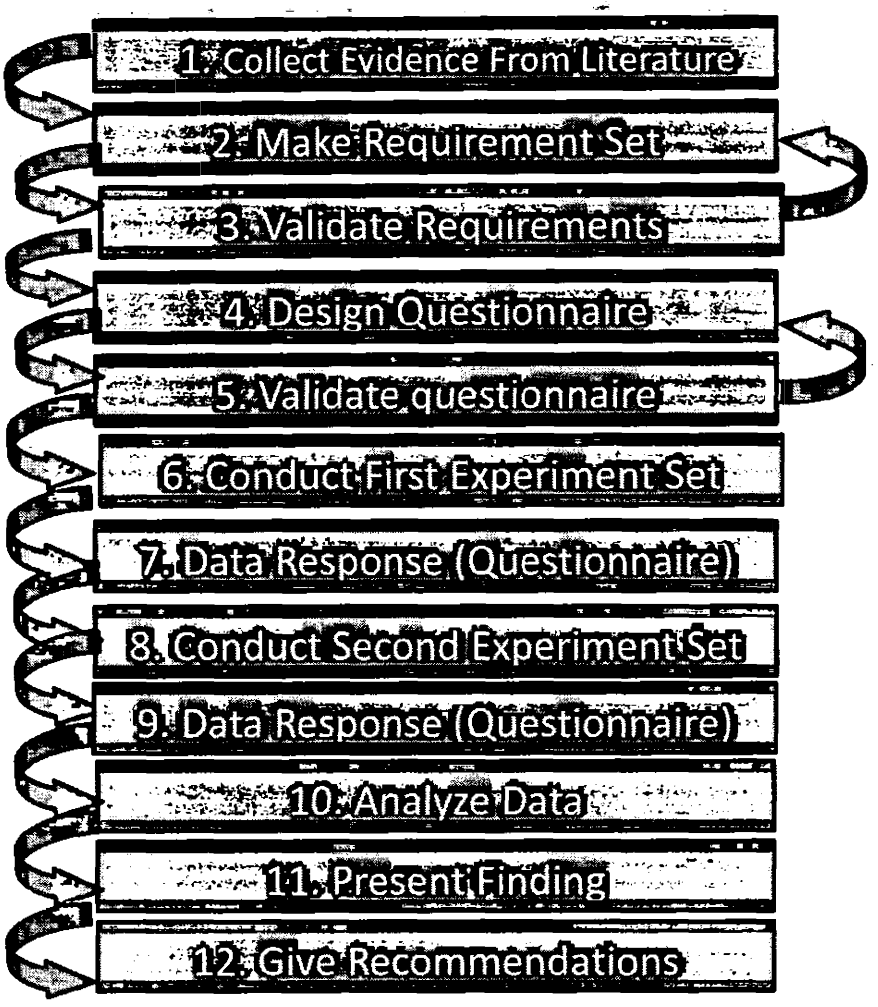

Figure 6, Research activity flow for completion of work.

Empirical studies are being performed in the field of software engineering by researcher to acquire and validate research data from software industry. There is a need to perform empirical studies to improve and develop processes, tools and methods for maintaining and developing softwares [53] [54] [55].

The established method for finding cause-effect relationships is to conduct controlled experiments where only a few variables vary. Controlled experiments in software engineering are performed from large to small scale as a part of research work. Controlled experiment is considered as most realistic approach if they are performed on actual task on real system with professionals of relevant field in their routine or usual environment.

While our focus is on controlled experiments, this does not mean that we are only concerned with laboratory, or in vitro experiments. Controlled experiment can also be conducted in vivo, in a more realistic environment than is possible in the artificial, sanitized laboratory situation [54]. However, the realistic environment can also be a weakness, because it may be too costly or impossible to manipulate an independent variable or to randomize treatments in real life. Thus, the amount of control varies on a continuum, and prioritizing between the validity types in an optimization problem, given the purpose of the experiment. Nevertheless, external validity is always of extreme importance whenever we wish to generalize from behaviour observed in the laboratory to behaviour outside the laboratory, or when we wish to generalize from one non-laboratory situation to another non-laboratory situation

Research Process

In this chapter, explanation about methodological considerations, the overall research process, and considerations on the research process is given in detail. The structure and nature of the research problem motivates us to move towards qualitative research approach as well as a design science approach, which is motivational factor for research process. Our research process consists of twelve stages:

a) Collect Evidence from Literature

b) Make Requirement Set

c) Validate requirements set

d) Design questionnaire

e) Validate questionnaire

f) Conducting first experiment

g) Data responses as a result of first experiment

h) Conducting second experiment

i) Data responses from second experiment

j) Overall data analysis

k) Presenting findings

l) Giving suggestions

Chapter # 5

Proposed Model (Solution)

5.1 Proposed Solution:

- To answer the given research question we have proposed a five step strategy.
  - In the first step we have collected, review literature and came up with a requirements set (Annexure I) which represents a real world situation.
    - Guidelines and recommendations are provided to suggest how to manage the RE process and use of tools for evaluation of the proposed objectives. We have chosen the MIS domain for this purpose due to most of the researcher adopt this technique.
  - In the second step requirement written according to the established format are put into the two stage experiment.
    - Pre Experiment (Experiment I)
    - Post Experiment (Experiment II)
  - In the third step we have chosen to conduct the experiment with industry experts in their respective environments so that the natural settings and their impact while validating the results can be maximized.
    - Careful consideration is taken in order to pick the participator set so that data validation may not become an issue.
  - In the fourth step prior to the execution of experiment, training is given to the participant regarding the novel approach and Requirements Engineering Tools.

- Finally in the firth step data is collected based on specially designed forms for the specific purpose of capturing the desired characteristics and results are obtained as per the perceptions of the practitioners for validation of the proposed are presented in the model.
    - Same will be evaluated to the industrial experts and research with the help of publications in conferences and journal publications.

5.2 Proposed Model for Improved Quality of Decision Making Process (Abstract level)

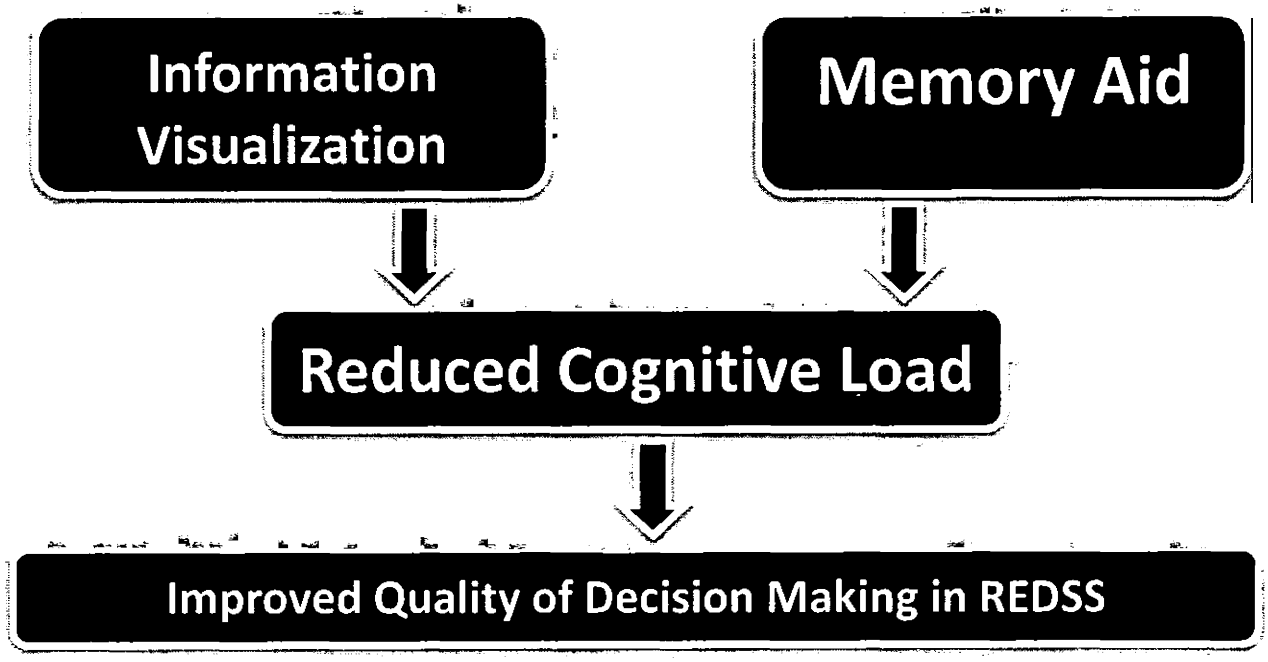

Figure 7, Proposed Model for Improved Quality of Decision Making Process (Abstract level).

5.3 Proposed Model for Improved Quality of Decision Making Process (Detail level)

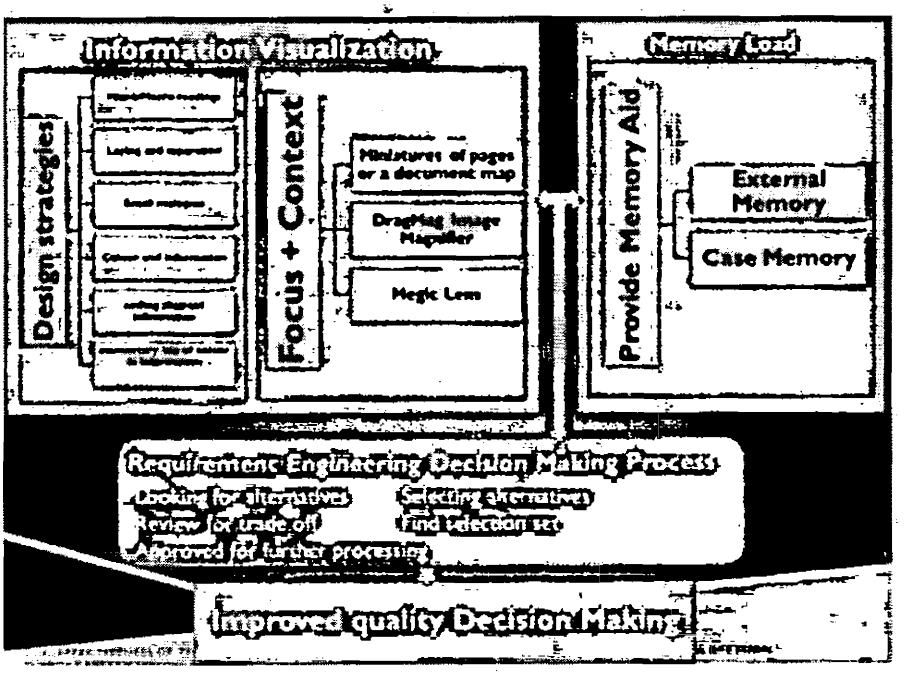

Figure 8, Proposed Model for Improved Quality of Decision Making Process (Detail level).

Summarise and Detail Information Provision

In literature mainly two methods are highlighted to manage cognitive load for requirements engineering decision support system. One of the techniques to succeed the cognitive load is to present requirements information in detail and in summarise form [45]. In decision making process, decision-maker has a huge volume of information to take consider and evaluate, and then presentation of information should be facilitated in a way that support the cognitive information processing. In order to judge the importance of information it is very important that information should have relation with the context for which it is being organised and presented. Otherwise it will be very time consuming and difficult process to understand and interpret information during

decision making process and it will be also very hard to establish its relationship with decision process. Consequently this will become the reason for an increase in cognitive load which will negatively affect the quality of decision making on the part of experts for requirements engineering decision support system

It is also evident from literature that one of the ways to decrease cognitive load is to provide information visualisation. Moreover the field information visualisation deals and supports design strategies and techniques to handle the problem of information presentation in term of summarise form and also detail form, so that this will help in reducing cognitive load of the RE decision-maker while making decision during requirements engineering. RE decision maker should be able to visualise the information in a way so that it, can comprehend it easily. The most common definition of Information visualisation is expressed as "*the use of computer-supported, interactive, visual representations of abstract data to amplify cognition*" [46]. Furthermore the prime objective of support in term of information visualisation augment human cognition capability that reduce mental exertion and improves quality of decision making at the time of decision making while dealing problems or issue related to requirements engineering [47]. One of the methods supported by literature is the concept of externalisation in which the information visualisation is facilitated or supported for cognition. The concept of data abstraction is used mostly by the RE decision-makers in requirements management, in RE decision-making. Data abstraction should be in more interactive and visual form to support decision makers for requirements engineering decision makers which consequently facilitate long way in

decision making process. This facility should be facilitated by requirements engineering tools to manage and manipulate the visual interpretations in the REDSS.

Another way to manage information visualisation Tufte et al [48] presented a series of design strategies that enable the communication of information. The major task is to handle and present complex data on a limited place which would be covered by eyes pan without any compromise on loss of information. Similarly it should help in understanding information in an easy way. For information mediation author stresses on good design which should be transparent and should help to keep focus to the information. More important is the information not the design because if design elements are having more impact on information presentation than attention is diverted from information where attention is drawn from information which reduces power of communication with reference to information. This factor creates communication gap and reduce quality of decision making by the RE decision maker. There are many elements as a part of design which includes certain thing included in the design space which is not information. These elements include text colour , text size, line spacing, colour schemes, foreground colour and background colour etc. moreover highlighting important information , readability of information, indentation, alignment of information, grouping of information, they all are very important and plays vital role in information presentation.

Major design strategies supported by the author are

- Micro/macro readings
- Layering and separation
- Small multiples
- Colour and information

Support Memory Aid

To reduce the cognitive load another very important guiding principle is memory aid, which helps RE decision-makers to make their job easier during decision making situations in decision making process. Memory aid benefit to manage certain aspects which otherwise have to be memorized and recalled when and where they are required. For benefiting from memory aid it is required to consider the support of external memory which support in recording basis or justification for previous requirements decisions. Ashcroft et all [49] for human information processing, human memory is considered as important aspect. Ability to remember or recalling things required lot of mental exertion which directly affects the cognitive load, which can be reduced by providing memory aid

Case memory is one of the ways for support of human memory in decision making to boost cognition ability of humans [50]. Case Memory facilitates the decision maker to record information as soft information. This soft information may include previous experiences, opinions of other experts etc. Voice recorder can be used to record information in the form of soft information to augment the RE decision makers in decision making situations.

According to Chen and Lee [51] "*It also reduces availability bias, which occurs due to the human tendency of using the availability heuristic, which means that humans judge the frequency of an occurrence based on how easily it comes to mind. On the other hand, how easily something is available in the human memory is not a good frequency estimate*". For reducing memory load Case Memory supports the decision-maker evoke relative information and past events and decisions. [52][51].

Chapter # 6

Results

6.1 Demographic Analysis

In this section we have presented the demographic analysis of software development companies of Pakistan. An overview of respondent designations and experience is also given. We sent our survey questionnaire to 25 teams of 25 of different companies and we got response from respondents. The average number of years of experience of a software development company in software development is 8 years and the average number of years of experience of the software development company in Requirement Engineering (RE) software development is 5. Among the respondents, almost all the respondents were experienced and working on senior positions. Among the respondents, there were seven software engineer, five Software developers, six project managers and seven system analysts. The average number of years of experience of a respondent is 8 and the average number of years of experience of a respondent in requirement engineering is 5. Moreover the range of total experience of the software industry is ranging between 5 and 14 years. Similarly the range of experience of requirement is lying between 2 and 10 years.

Respondent	Frequency
Software Engineer	7
Software Developer	5
Project Manager	6
System Analyst	7
Total participants	25

Table 1 Participants detail for experiment

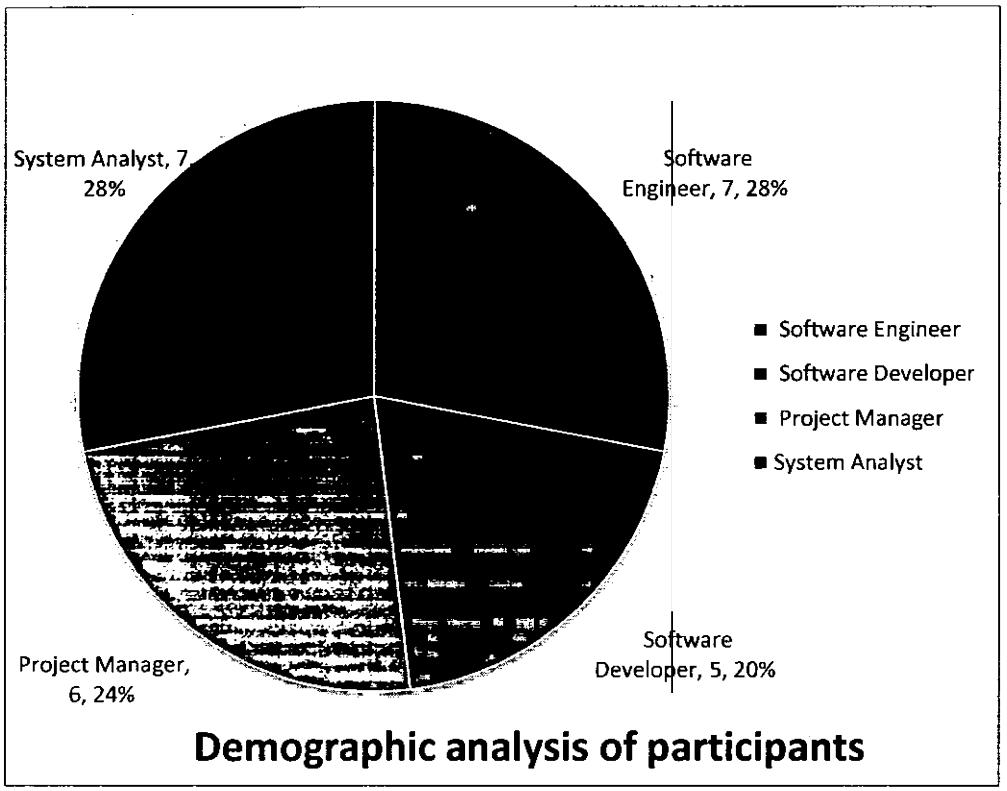

Figure 9, Demographic Analysis of Participants

6.2 Comparison of factors that affect Cognitive Load and RE Decision making process

In this section an analysis is given about the group of factors that are directly affecting the decision making process and the quality of decision. The table shows the frequencies of sub factors used for decision making activities. The following table shows the most commonly used and least commonly used for decision making process.

Factors	Related questions form Questionnaire								Count
RE Tools	16	17	18	19	21				5
Memory Aid	26	27	30	33	36	37			6
Manpower	13	34	38	42	48	13			6
Information Visualization	20	22	23	24	25	31	40	41	8
Standardization	49	50							2
Time Factor	14	15	32	35	44	45	46	47	8

Table 2 Comparison of different parameters

6.3 Comparison of factors that are directly affecting cognitive load during decision making

In this section an analysis is given about that factor which is particular directly affecting the process of decision making during requirement engineering decision support system. These factors are also dependent on each other. These factors include use of RE tools, their usefulness of these tools, ease of use of these tools, effect of memory load on decision making process, total stress during decision making process, support in term of information visualization given by RE tools, understanding of cognitive load, visual separation and provision of memory load. For detail analysis T test is performed for which detail is as follows

This lesson explains how to conduct a hypothesis test for the difference between paired means. The test procedure, called the **matched-pairs t-test**, is appropriate when the following conditions are met:

- The sampling method for each sample is simple random sampling.
- The test is conducted on paired data. (As a result, the data sets are *not* independent.)
    - Each sample is drawn from a normal or near-normal population. Generally, the sampling distribution will be approximately normal if any of the following conditions apply.
      The population distribution is normal.
    - The sample data are symmetric, unimodal, without outliers, and the sample size is 15 or less.
    - The sample data are slightly skewed, unimodal, without outliers, and the sample size is 16 to 40.
    - The sample size is greater than 40, without outliers.
    - This approach consists of four steps: (1) state the hypotheses, (2) formulate an analysis plan, (3) analyze sample data, and (4) interpret results.

State the Hypotheses

Every hypothesis test requires the analyst to state a null hypothesis and an alternative hypothesis. The hypotheses are stated in such a way that they are mutually exclusive. That is, if one is true, the other must be false; and vice versa.

The hypotheses concern a new variable ***d***, which is based on the difference between paired values from two data sets.

$$d = x1 - x2$$

Where x1 is the value of variable x in the first data set and x2 is the value of the variable from the second data set that is paired with x1.

The table below shows three sets of null and alternative hypotheses. Each makes a statement about how the true difference in population values μd is related to some hypothesized value D. (In the table, the symbol ≠ means "not equal to ".)

Set	Null hypothesis	Alternative hypothesis	Number of tails
1	$\mu d = D$	$\mu d \neq D$	2
2	$\mu d > D$	$\mu d < D$	1
3	$\mu d < D$	$\mu d > D$	1

Table 3

The first set of hypotheses (Set 1) is an example of a two-tailed test, since an extreme value on either side of the sampling distribution would cause a researcher to reject the null hypothesis. The other two sets of hypotheses (Sets 2 and 3) are one-tailed tests, since an extreme value on only one side of the sampling distribution would cause a researcher to reject the null hypothesis.

Formulate an Analysis Plan

The analysis plan describes how to use sample data to accept or reject the null hypothesis. It should specify the following elements.

Significance level. Often, researchers choose significance levels equal to 0.01, 0.05, or 0.10; but any value between 0 and 1 can be used.

Test method. Use the matched-pairs t-test to determine whether the difference between sample means for paired data is significantly different from the hypothesized difference between population means.

Analyze Sample Data

Using sample data, find the standard deviation, standard error, degrees of freedom, test statistic, and the P-value associated with the test statistic.

Standard deviation. Compute the standard deviation (*sd*) of the differences computed from n matched pairs.

$$sd = \sqrt{\left[\Sigma(di - d)^2 / (n - 1) \right]} \quad (2)$$

where di is the difference for pair *i*, d is the sample mean of the differences, and n is the number of paired values.

Standard error. Compute the standard error (SE) of the sampling distribution of d.

$$SE = sd * \sqrt{\{ (1/n) * (1 - n/N) * [N/(N - 1)] \}} \quad (3)$$

Where *sd* is the standard deviation of the sample difference, *N* is the population size, and n is the sample size. When the population size is much larger (at least 10 times larger) than the sample size, the standard error can be approximated by:

$$SE = sd / \sqrt{(n)} \quad (4)$$

Degrees of freedom. The degrees of freedom (*DF*) is: $DF = n - 1$.

Test statistic. The test statistic is a t-score (t) defined by the following equation.

$t = [(x1 - x2) - D] / SE = (d - D) / SE$ 5

Where x1 is the mean of sample 1, x2 is the mean of sample 2, d is the mean difference between paired values in the sample, D is the hypothesized difference between population means, and SE is the standard error.

- P-value. The P-value is the probability of observing a sample statistic as extreme as the test statistic. Since the test statistic is a t-score, use the t Distribution Calculator to assess the probability associated with the t-score, having the degrees of freedom computed above. (See the sample problem at the end of this lesson for guidance on how this is done.)

Interpret Results

If the sample findings are unlikely, given the null hypothesis, the researcher rejects the null hypothesis. Typically, this involves comparing the P-value to the significance level, and rejecting the null hypothesis when the P-value is less than the significance level.

T Distribution Calculator: Online Statistical Table

The t distribution calculator makes it easy to compute cumulative probabilities, based on t scores; or to compute t scores, based on cumulative probabilities.

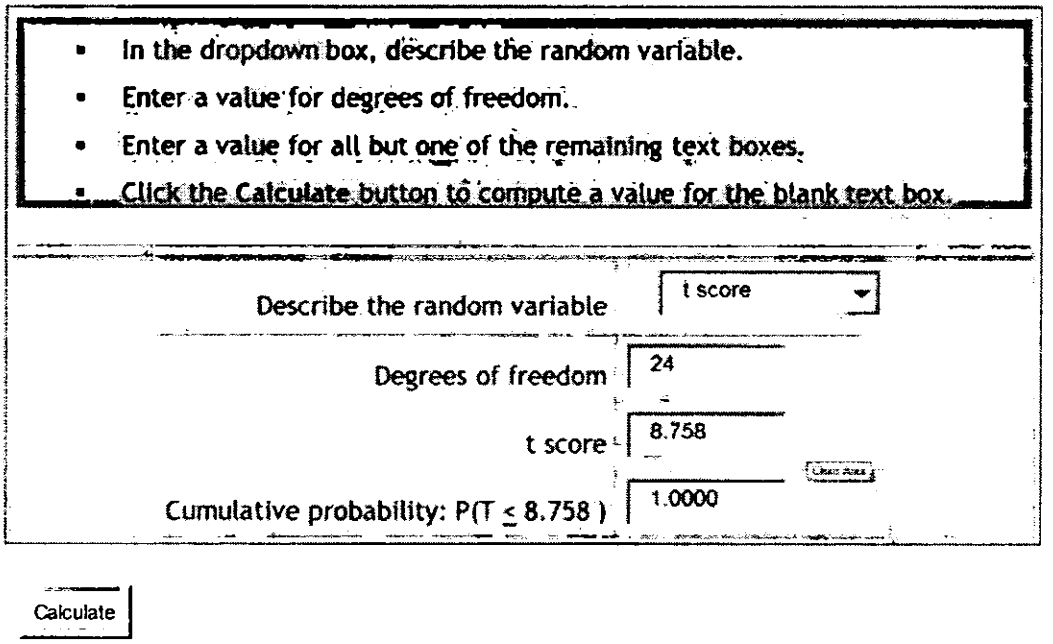

Figure 10, T Distribution Calculator - on line calculator

Success and failure with respect to use of RE Tools during experiments

Use of RE Tools							
Pair	**After**	**Before**	**Difference, d**	$(d-\bar{d})^2$	**Standard deviation**	**Standard error**	**Test statistic**
1	**6**	**0**	6	0.58	2.634	0.527	9.945
2	**9**	**0**	9	14.14			
3	**4**	**0**	4	1.54			
4	**8**	**0**	8	7.62			
5	**8**	**0**	8	7.62			
6	**6**	**0**	6	0.58			
7	**4**	**0**	4	1.54			
8	**8**	**2**	6	0.58			
9	**6**	**0**	6	0.58			
10	**6**	**6**	0	27.46			
11	**4**	**0**	4	1.54			
12	**6**	**6**	0	27.46			
13	**8**	**0**	8	7.62			
14	**6**	**0**	6	0.58			
15	**4**	**0**	4	1.54			
16	**6**	**6**	0	27.46			
17	**4**	**2**	2	10.50			
18	**6**	**0**	6	0.58			
19	**8**	**0**	8	7.62			
20	**6**	**0**	6	0.58			
21	**4**	**0**	4	1.54			
22	**6**	**0**	6	0.58			
23	**8**	**0**	8	7.62			
24	**8**	**0**	8	7.62			
25	**6**	**2**	4	1.54			
Average	**6.20**	**0.96**	**5.24**	**166.56**			
Maximum	9	6					
Minimum	4	0					
Variance	2.50	4.04					

Table 4, data collection on use of RE tools

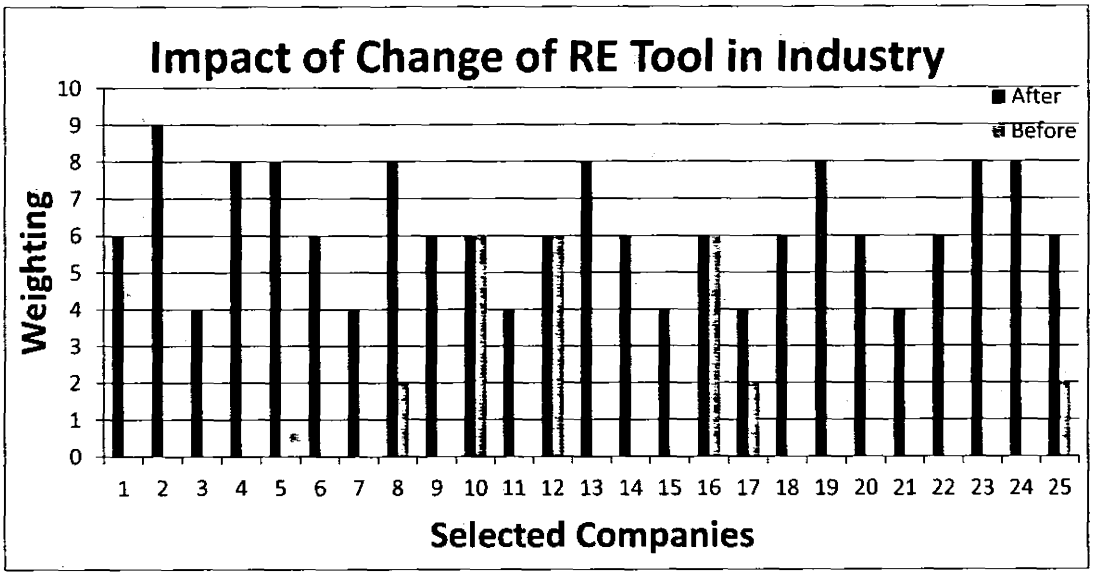

Figure 11 a, use of RE tools in Software Industry

Results Interpretation

Null Hypothesis Ho: use of RE tools during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: use of RE tools during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 2.634$

$SE = s / \text{sqrt}(n)$

$= 3.586 / [\ \text{sqrt}(25)\ ] = 0.527$

$DF = n - 1 = 25 - 1 = 24$

$t = [\ (x1 - x2) - D\ ] / SE = (d - D) / SE = 9.945$

Degrees of freedom	24
t score	9.945
Cumulative probability: P(T ≤ 9.945)	1.0000

Figure 11 b

Interpret results. The result given above proves that use of tools is having great impact on quality of decision making.

Success and failure with respect to use of RE Tools during experiments

Helpful in Reducing Cognitive Load							
Pair	**After**	**Before**	**Difference, d**	$(d-\bar{d})^2$	**Standard deviation**	**Standard error**	**Test statistic**
1	4	0	4	0.03	2.375	0.475	8.758
2	6	0	6	3.39			
3	8	0	8	14.75			
4	4	0	4	0.03			
5	4	0	4	0.03			
6	6	0	6	3.39			
7	4	0	4	0.03			
8	4	2	2	4.67			
9	6	0	6	3.39			
10	4	6	-2	37.95			
11	4	0	4	0.03			
12	6	6	0	17.31			
13	6	0	6	3.39			
14	6	0	6	3.39			
15	4	0	4	0.03			
16	6	6	0	17.31			
17	4	2	2	4.67			
18	4	0	4	0.03			
19	6	0	6	3.39			
20	6	0	6	3.39			
21	6	0	6	3.39			
22	4	0	4	0.03			
23	6	0	6	3.39			
24	6	0	6	3.39			
25	4	2	2	4.67			
Average	**5.12**	**0.96**	**4.16**	**135.36**			
Maximum	8	6					
Minimum	4	0					
Variance	1.36	4.04					

Table 5, Helpful in Reducing Cognitive Load

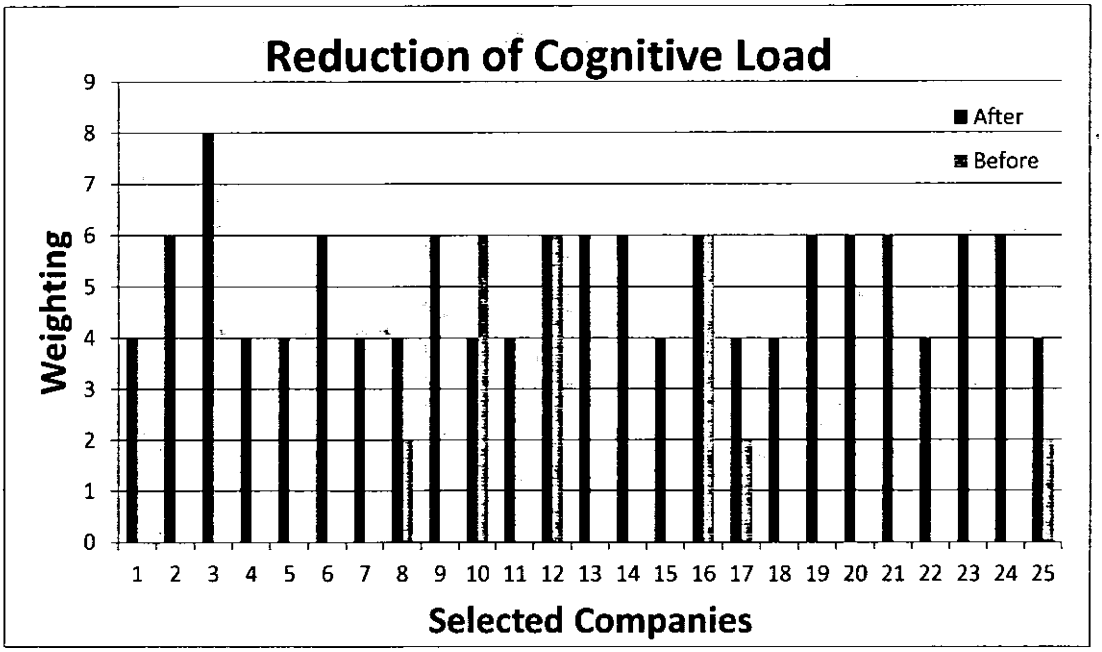

Figure 12 a

Null Hypothesis Ho: use of RE tools during requirement engineering decision making process is not helpful in reduction of cognitive load

Alternative Hypothesis H1: use of RE tools during requirement engineering decision making process is helpful either increasing/decreasing of cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 2.375$

$SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.475$

$DF = n - 1 = 25 - 1 = 24$

$t = [\ (x1 - x2) - D\ ] / SE = (d - D) / SE = 8.758$

Degrees of freedom	24
t score	8.758
Cumulative probability: P(T ≤ 8.758)	1.0000

Figure 12 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making

Success and failure with respect to ease of use of RE Tools during experiments

Ease of Use of RE Tools							
Pair	After	Before	Difference, d	$(d-\bar{d})^2$	Standard deviation	Standard error	Test statistic
1	7	0	7	2.07	2.485	0.497	11.189
2	8	0	8	5.95			
3	6	0	6	0.19			
4	6	0	6	0.19			
5	8	0	8	5.95			
6	6	0	6	0.19			
7	6	0	6	0.19			
8	6	2	4	2.43			
9	8	0	8	5.95			
10	6	6	0	30.91			
11	6	0	6	0.19			
12	8	8	0	30.91			
13	6	0	6	0.19			
14	6	0	6	0.19			
15	4	0	4	2.43			
16	8	8	0	30.91			
17	6	2	4	2.43			
18	6	0	6	0.19			
19	6	0	6	0.19			
20	8	0	8	5.95			
21	6	0	6	0.19			
22	8	0	8	5.95			
23	8	0	8	5.95			
24	8	0	8	5.95			
25	6	2	4	2.43			
Average	**6.68**	**1.12**	**5.56**	**148.16**			
Maximum	8	8					
Minimum	4	0					
Variance	1.23	6.03					

Table 6, Ease of Use of RE Tools

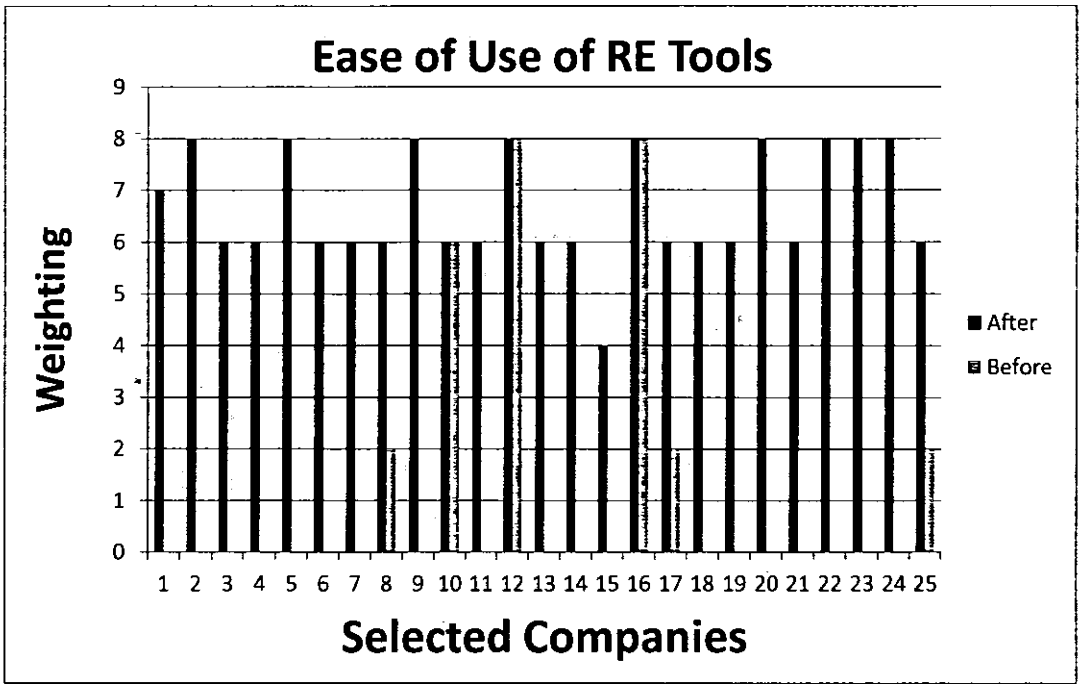

Figure 13 a

Null Hypothesis Ho: use of RE tools is not easy during requirement engineering decision making process in reduction of cognitive load

Alternative Hypothesis H1: use of RE tools leads to ease or difficulty during requirement engineering decision making process in managing cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 2.485$

$SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.497$

$DF = n - 1 = 25 - 1 = 24$

$t = [\ (x1 - x2) - D\ ] / SE = (d - D) / SE = 11.189$

Degrees of freedom	24
t score	11.189
Cumulative probability: P(T ≤ 11.189)	1.0000

Figure 13 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making

Success and failure with respect to memory load during experiments

Change in Memory Load							
Pair	After	Before	Difference, d	$(d-\bar{d})^2$	Standard deviation	Standard error	Test statistic
1	6	9	-3	0.58	0.597	0.119	-18.754
2	5	8	-3	0.58			
3	7	9	-2	0.06			
4	6	9	-3	0.58			
5	6	8	-2	0.06			
6	6	8	-2	0.06			
7	5	7	-2	0.06			
8	7	9	-2	0.06			
9	6	9	-3	0.58			
10	7	9	-2	0.06			
11	6	9	-3	0.58			
12	6	9	-3	0.58			
13	8	9	-1	1.54			
14	5	7	-2	0.06			
15	7	9	-2	0.06			
16	6	7	-1	1.54			
17	6	8	-2	0.06			
18	7	9	-2	0.06			
19	5	7	-2	0.06			
20	6	9	-3	0.58			
21	6	9	-3	0.58			
22	5	7	-2	0.06			
23	6	8	-2	0.06			
24	7	9	-2	0.06			
25	7	9	-2	0.06			
Average	**6.16**	**8.40**	**-2.24**	**8.56**			
Maximum	8	9					
Minimum	5	7					
Variance	0.64	0.67					

Table 7, Change in Memory Load

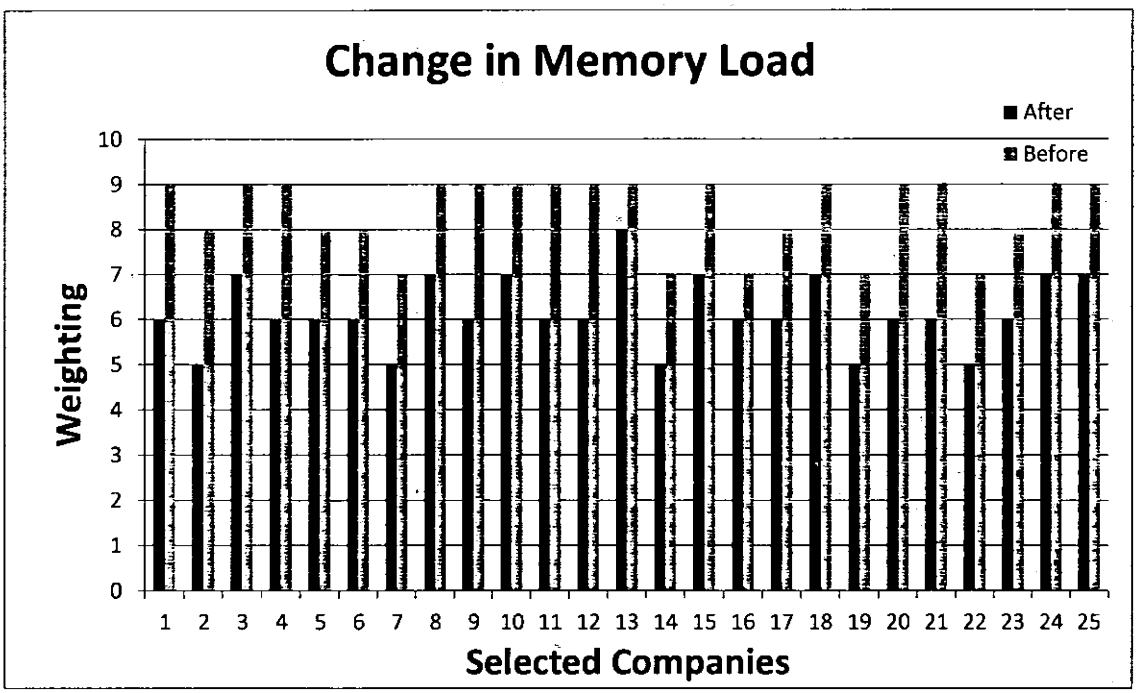

Figure 14 a

Null Hypothesis Ho: memory load during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: memory load during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 0.597$ $SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.119$ $DF = n - 1 = 25 - 1 = 24$ $t = [\ (x1 - x2) - D\ ] / SE = (d - D) / SE = -18.754$	Degrees of freedom: 24 t score: -18.754 Cumulative probability: P(T ≤ -15.087): 0.0000

Figure 14 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making in term of memory load

Success and failure with respect to stress during experiments

Stress Level							
Pair	**After**	**Before**	**Difference, d**	$(d-\bar{d})^2$	**Standard deviation**	**Standard error**	**Test statistic**
1	**6**	**9**	-3	0.52	0.614	0.123	-18.575
2	**5**	7	-2	0.08			
3	**6**	**9**	-3	0.52			
4	7	**9**	-2	0.08			
5	**8**	**10**	-2	0.08			
6	**6**	**8**	-2	0.08			
7	7	**10**	-3	0.52			
8	**6**	**8**	-2	0.08			
9	7	**9**	-2	0.08			
10	**6**	**9**	-3	0.52			
11	7	**9**	-2	0.08			
12	7	**8**	-1	1.64			
13	**6**	**8**	-2	0.08			
14	**5**	7	-2	0.08			
15	7	**9**	-2	0.08			
16	**5**	7	-2	0.08			
17	**6**	**9**	-3	0.52			
18	**6**	**8**	-2	0.08			
19	**6**	**8**	-2	0.08			
20	7	**9**	-2	0.08			
21	7	**9**	-2	0.08			
22	**6**	**9**	-3	0.52			
23	**5**	**9**	-4	2.96			
24	**6**	**8**	-2	0.08			
25	**6**	**8**	-2	0.08			
Average	**6.24**	**8.52**	**-2.28**	**9.04**			
Maximum	8	10					
Minimum	5	7					
Variance	0.61	0.68					

Table 8, Stress Level

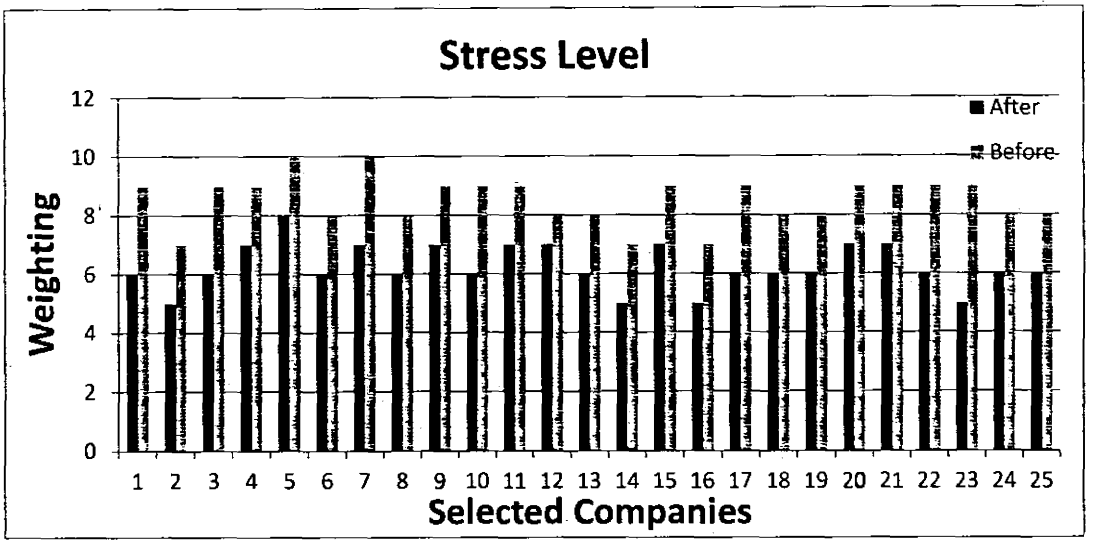

Figure 15 a

Null Hypothesis Ho: Stress during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: Stress during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 0.654$ $SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.123$ $DF = n - 1 = 25 - 1 = 24$ $t = [(x1 - x2) - D] / SE = (d - D) / SE =$ -18.575	Degrees of freedom: 24 t score: -18.575 Cumulative probability: P(T < -18.575): 0.0000

Figure 15 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making in term of memory load

Success and failure with respect to Information visualization during experiments

Information Visualization							
Pair	After	Before	Difference, d	$(d-\bar{d})^2$	Standard deviation	Standard error	Test statistic
1	5	2	3	0.16	0.816	0.163	15.922
2	7	4	3	0.16			
3	6	4	2	0.36			
4	5	2	3	0.16			
5	7	2	5	5.76			
6	6	4	2	0.36			
7	5	4	1	2.56			
8	6	4	2	0.36			
9	5	2	3	0.16			
10	4	2	2	0.36			
11	5	2	3	0.16			
12	6	4	2	0.36			
13	5	2	3	0.16			
14	6	4	2	0.36			
15	5	2	3	0.16			
16	7	4	3	0.16			
17	6	2	4	1.96			
18	5	2	3	0.16			
19	6	4	2	0.36			
20	6	4	2	0.36			
21	5	2	3	0.16			
22	5	2	3	0.16			
23	4	2	2	0.36			
24	4	2	2	0.36			
25	6	4	2	0.36			
Average	**5.48**	**2.88**	**2.60**	**16.00**			
Maximum	7	4					
Minimum	4	2					
Variance	0.76	1.03					

Table 9, Information Visualization

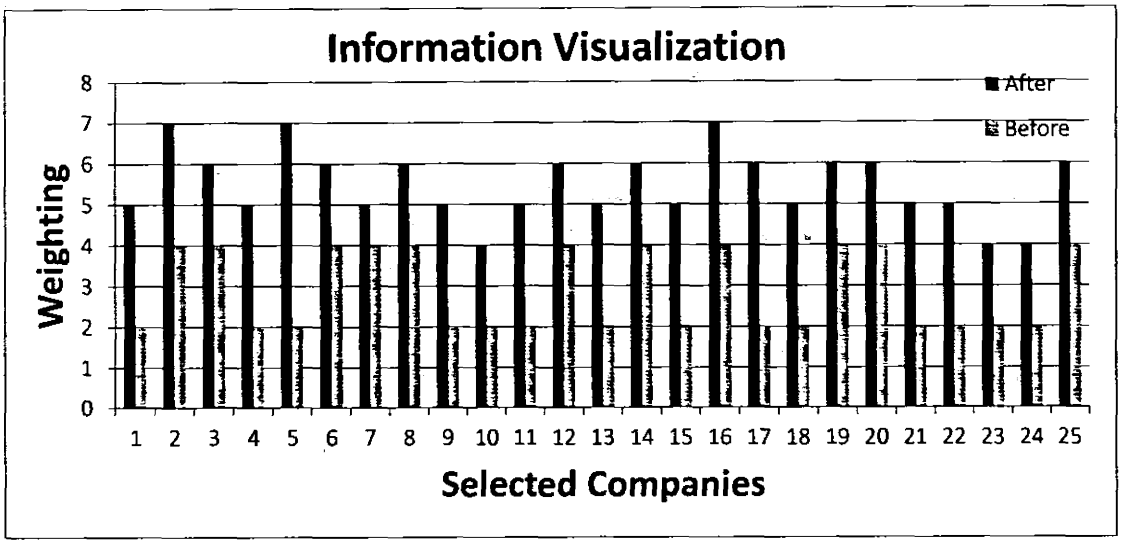

Figure 16 a

Null Hypothesis Ho: Information visualization during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: Information visualization during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 0.816$

$SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.163$

$DF = n - 1 = 25 - 1 = 24$

$t = [(\bar{x}1 - \bar{x}2) - D\ ] / SE = (\bar{d} - D) / SE = 15.922$

Degrees of freedom	24
t score	15.922
Cumulative probability: P(T ≤ 15.922)	1.0000

Figure 16 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making in term of memory load

Success and failure with respect to understanding of Cognitive load during experiments

Understanding of Cognitive Load							
Pair	After	Before	Difference, d	$(d-\bar{d})^2$	Standard deviation	Standard error	Test statistic
1	8	6	2	0.46	0.476	0.095	13.863
2	6	5	1	0.10			
3	8	7	1	0.10			
4	8	7	1	0.10			
5	8	6	2	0.46			
6	10	9	1	0.10			
7	8	7	1	0.10			
8	8	6	2	0.46			
9	8	6	2	0.46			
10	8	7	1	0.10			
11	8	7	1	0.10			
12	10	9	1	0.10			
13	8	7	1	0.10			
14	8	7	1	0.10			
15	8	6	2	0.46			
16	8	6	2	0.46			
17	8	7	1	0.10			
18	8	6	2	0.46			
19	10	9	1	0.10			
20	8	7	1	0.10			
21	8	7	1	0.10			
22	8	6	2	0.46			
23	10	9	1	0.10			
24	8	7	1	0.10			
25	10	9	1	0.10			
Average	**8.32**	**7.00**	**1.32**	**5.44**			
Maximum	10	9					
Minimum	6	5					

Table 10, Understanding of Cognitive Load

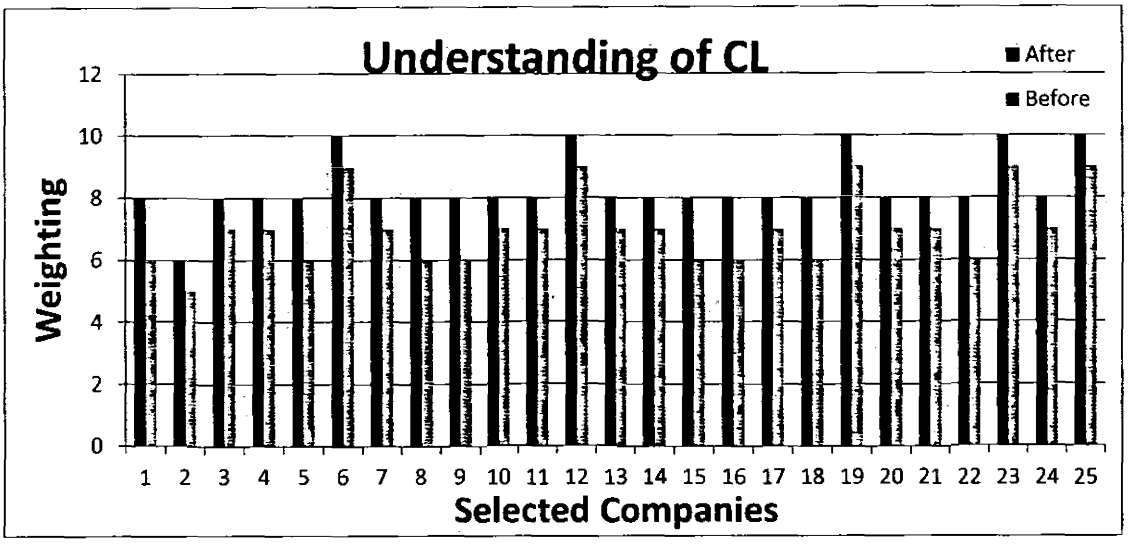

Figure 17 a

Null Hypothesis Ho: Understanding of cognitive load during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: Understanding of cognitive load during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\left[(\Sigma(di - \bar{d})^2 / (n - 1) \right] = 0.476$

$SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.095$

$DF = n - 1 = 25 - 1 = 24$

$t = [(x1 - x2) - D] / SE = (d - D) / SE = 13.863$

Degrees of freedom	24
t score	13.863
Cumulative probability: P(T ≤ 13.863)	1.0000

Figure 17 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making in term of memory load

Success and failure with respect to Visual Separation on Cognitive load during experiments

Provision of Visual Separation							
Pair	After	Before	Difference, d	$(d-\bar{d})^2$	Standard deviation	Standard error	Test statistic
1	4	2	2	0.04	0.707	0.141	15.556
2	4	2	2	0.04			
3	5	4	1	1.44			
4	4	2	2	0.04			
5	5	2	3	0.64			
6	4	2	2	0.04			
7	6	4	2	0.04			
8	4	2	2	0.04			
9	4	2	2	0.04			
10	6	4	2	0.04			
11	5	2	3	0.64			
12	6	4	2	0.04			
13	7	4	3	0.64			
14	6	2	4	3.24			
15	5	4	1	1.44			
16	6	4	2	0.04			
17	5	2	3	0.64			
18	6	4	2	0.04			
19	6	4	2	0.04			
20	7	6	1	1.44			
21	6	4	2	0.04			
22	5	2	3	0.64			
23	6	4	2	0.04			
24	4	2	2	0.04			
25	5	2	3	0.64			
Average	**5.24**	**3.04**	**2.20**	**12.00**			
Maximum	7	6					
Minimum	4	2					
Variance	0.94	1.37					

Table 11, Provision of Visual Separation

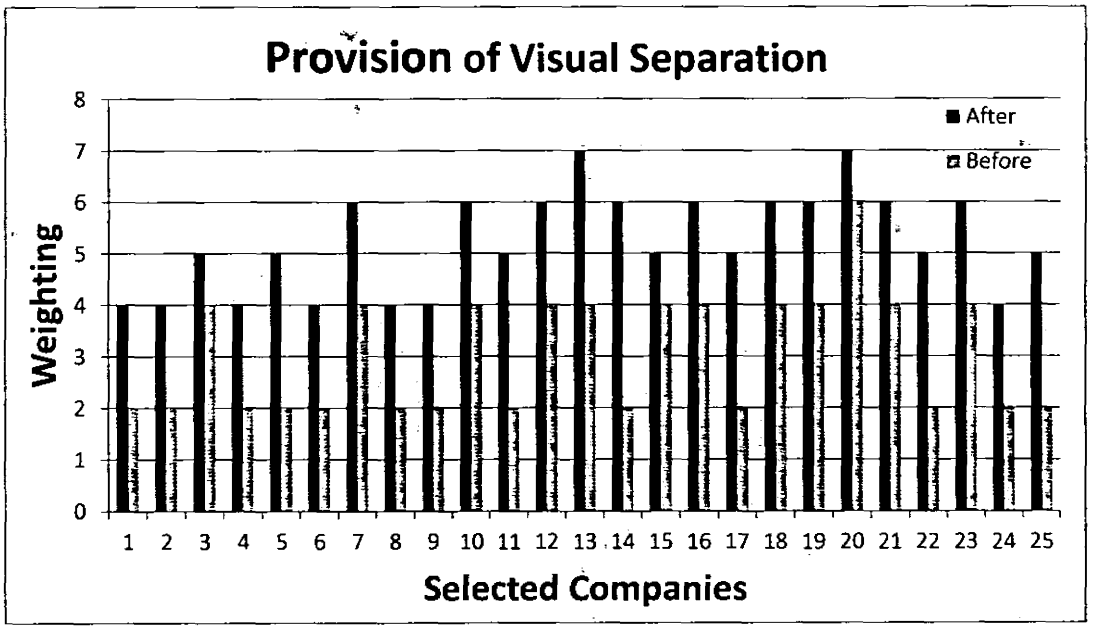

Figure 18 a

Null Hypothesis Ho: visual separation support during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: visual separation support during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}[\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 0.707$ $SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.141$ $DF = n - 1 = 25 - 1 = 24$ $t = [\ (x1 - x2) - D\ ] / SE = (d - D) / SE = 15.556$	Degrees of freedom: 24 t score: 15.556 Cumulative probability: P(T ≤ 15.556): 1.0000

Figure 18 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making in term of memory load

Success and failure with provision of memory load on Cognitive load during experiments

Provision of Memory Aid							
Pair	After	Before	Difference, d	$d - \bar{d}$	Standard deviation	Standard error	Test statistic
1	2	2	0	1.54	1.052	0.210	5.894
2	2	2	0	1.54			
3	4	4	0	1.54			
4	4	4	0	1.54			
5	2	2	0	1.54			
6	2	2	0	1.54			
7	2	2	0	1.54			
8	4	4	0	1.54			
9	6	4	2	0.58			
10	5	2	3	3.10			
11	4	2	2	0.58			
12	7	6	1	0.06			
13	5	4	1	0.06			
14	6	4	2	0.58			
15	5	2	3	3.10			
16	7	6	1	0.06			
17	5	4	1	0.06			
18	4	2	2	0.58			
19	7	6	1	0.06			
20	4	2	2	0.58			
21	5	2	3	3.10			
22	4	2	2	0.58			
23	5	4	1	0.06			
24	4	2	2	0.58			
25	4	2	2	0.58			
Average	4.36	3.12	1.24	26.56			
Maximum	7	6					
Minimum	2	2					
Variance	2.41	2.03					

Table 12, Provision of Memory Aid

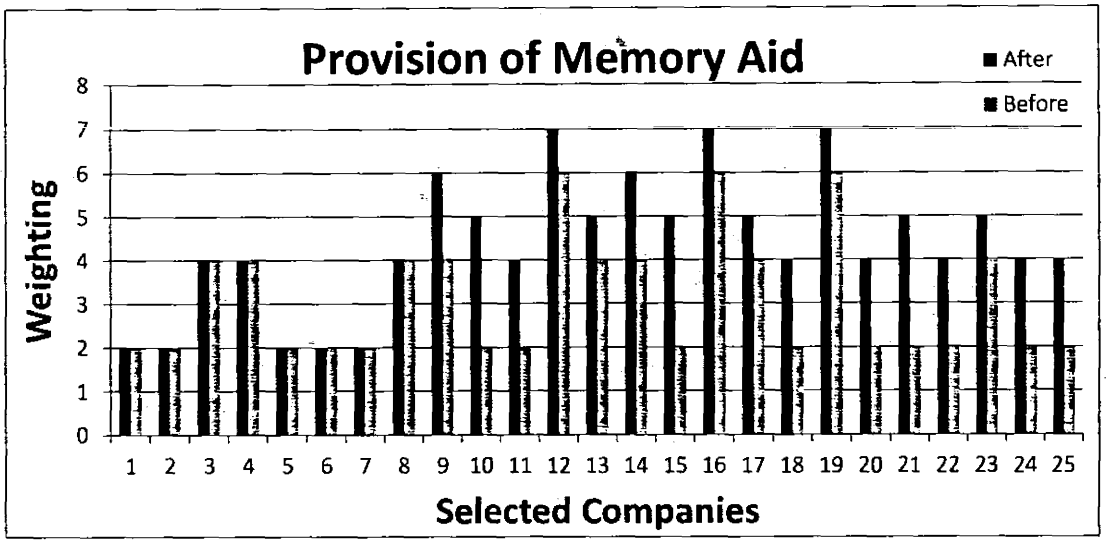

Figure 19 a

Null Hypothesis Ho: visual separation support during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: visual separation support during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 1.052$

$SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.210$

$DF = n - 1 = 25 - 1 = 24$

$t = [\ (x1 - x2) - D\ ] / SE = (d - D) / SE = 5.894$

Degrees of freedom	24
t score	5.894
Cumulative probability: P(T ≤ 5.894)	1.0000

Figure 19 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making in term of memory load

Success and failure with respect to colour text for abstraction help to reduce Cognitive load during experiments

Use of RE Tools							
Pair	After	Before	Difference, d	$(d-\bar{d})^2$	Standard deviation	Standard error	Test statistic
1	3	0	3	0.31	0.917	0.183	13.311
2	4	2	2	0.19			
3	4	2	2	0.19			
4	4	2	2	0.19			
5	3	0	3	0.31			
6	5	2	3	0.31			
7	4	2	2	0.19			
8	4	2	2	0.19			
9	5	2	3	0.31			
10	4	4	0	5.95			
11	4	2	2	0.19			
12	4	2	2	0.19			
13	3	0	3	0.31			
14	5	2	3	0.31			
15	4	2	2	0.19			
16	5	2	3	0.31			
17	4	2	2	0.19			
18	3	0	3	0.31			
19	5	2	3	0.31			
20	4	0	4	2.43			
21	5	2	3	0.31			
22	5	2	3	0.31			
23	4	0	4	2.43			
24	3	2	1	2.07			
25	5	4	1	2.07			
Average	**4.12**	**1.68**	**2.44**	**20.16**			
Maximum	5	4					
Minimum	3	0					
Variance	0.53	1.23					

Table 13, Use of RE Tools

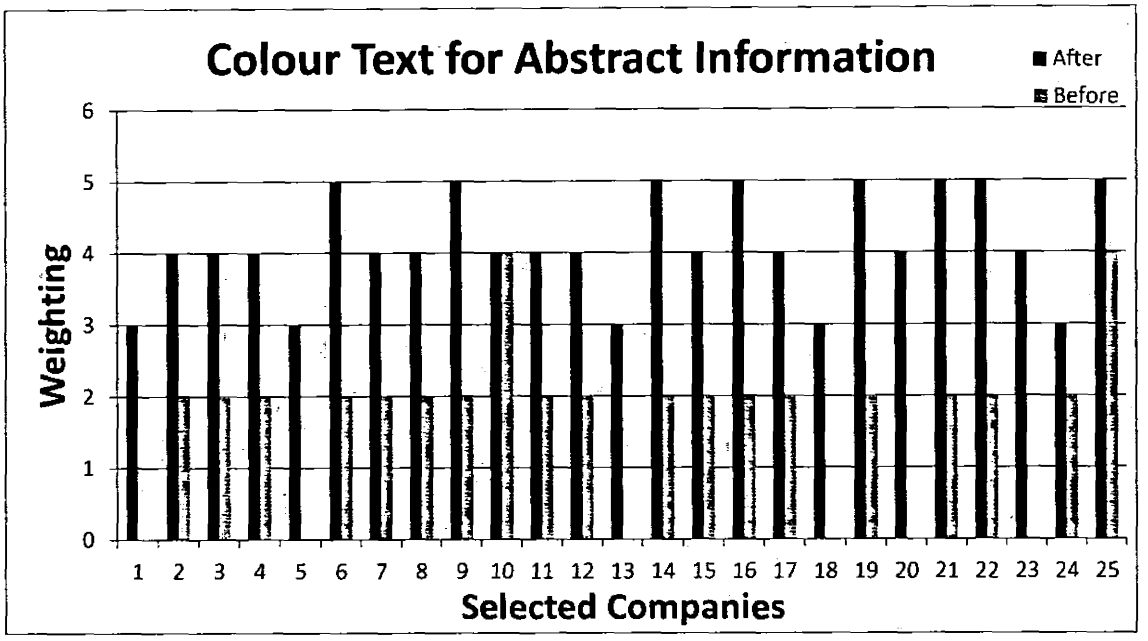

Figure 20 a

Null Hypothesis Ho: colour text for abstraction during requirement engineering decision making process has no impact on reduction of cognitive load

Alternative Hypothesis H1: colour text for abstraction during requirement engineering decision making process either increase or decrease cognitive load

Analysis of Data Using data, we compute the standard deviation of the differences (s), the standard error (SE) of the mean difference, the degrees of freedom (DF), and the t-score test statistic (t).

$s = \text{sqrt}\ [\ (\Sigma(di - \bar{d})^2 / (n - 1)\ ] = 0.917$

$SE = s / \text{sqrt}(n) = 3.586 / [\ \text{sqrt}(22)\ ] = 0.183$

$DF = n - 1 = 25 - 1 = 24$

$t = [\ (x1 - x2) - D\ ] / SE = (d - D) / SE = 13.311$

Degrees of freedom	24
t score	13.311
Cumulative probability: P(T ≤ 13.311)	1.0000

Figure 20 b

Interpret results. The result given above proves that use of tools are helpful and having great impact of quality of decision making in term of memory load

Experts Total Experience

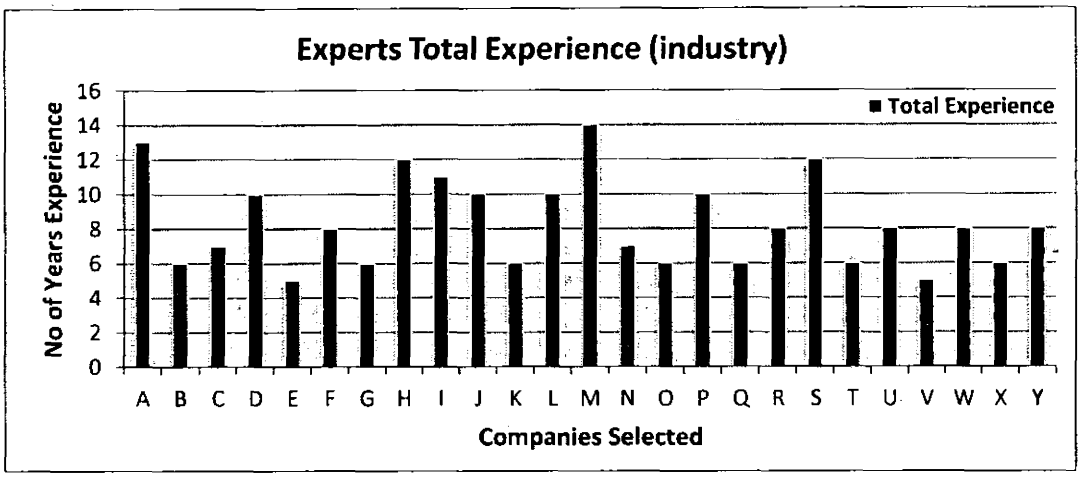

Figure 21

The above graph is reflection of total experience of each expert chosen from 25 different organizations for completing experiment. This experiment is ranging experience of expert from 5 to 14 years to support endorsement of results and maturity of expert's selection. The mean value for total experience is 8.32 years; minimum value is 5 years while maximum experience is 14 years.

Experts total Experience for Requirement Engineering in Industry

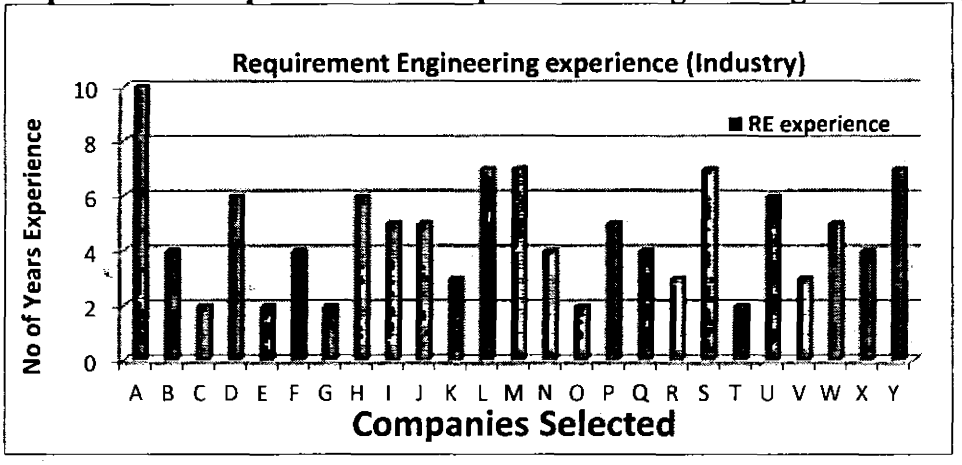

Figure 22

The comparison of selected experts from selected companies is show in the above graph. The highest value for their experience is 10 years as compare to minimum value of 02 years. Moreover the mean value for their experience is 4.6 years. This information is imitating that wide range of experts is considered for experiment.

Experience and no of projects for Requirement Engineering in Industry

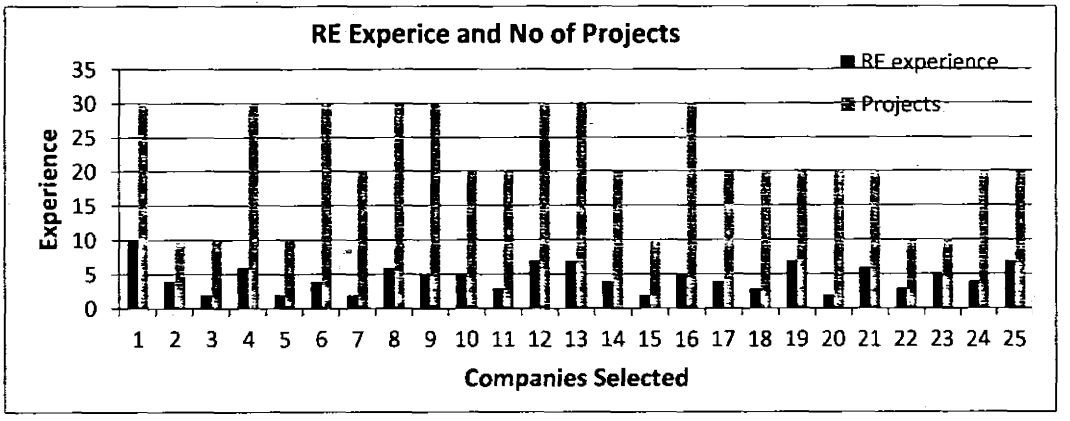

Figure 23

The graph is reflection of experts experience in the domain of Requirements Engineering in selected organization and no of projects completed so far by these individuals. Requirements Engineers experience mean value is 4.6, min experience value is 2 and maximum value is 10. Similarly Projects completed by these experts mean value is 20.80, minimum value is 10 and maximum value is 30. This comparison is indicating that expert is not having enough experience in the field of requirements engineering as compare to the no of projects completed by these experts.

Experts total Experience, understanding and no of projects for Requirement Engineering in Industry

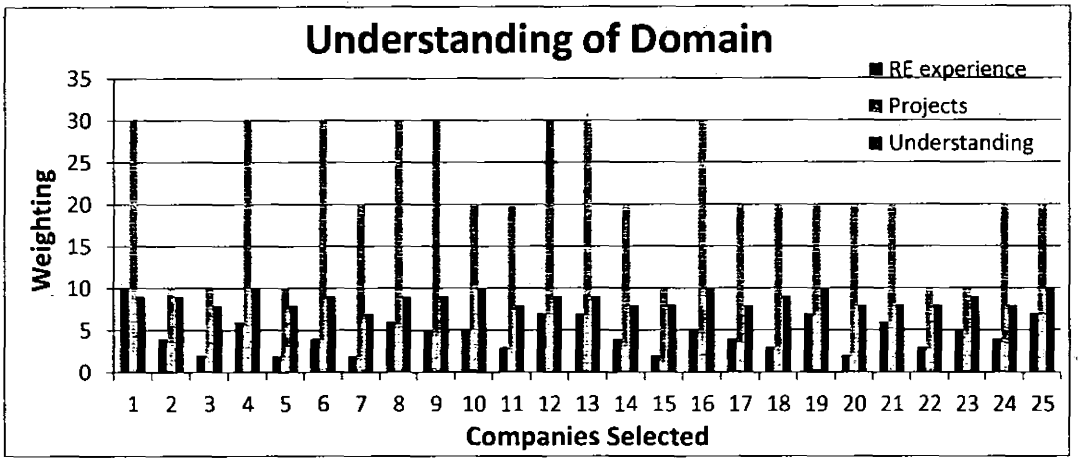

Figure 24

Lack of understanding of Requirements Engineering field makes decision making difficult in Requirement Engineering process. Therefore results are reflecting that mean value is 8.72, maximum value is 10 and minimum value is 7, which is strongly evident that most of the experts are well literate about the importance of the concept. Requirements Engineers experience mean value is 4.6, min experience value is 2 and maximum value is 10. Similarly Projects completed by these experts mean value is 20.80, minimum value is 10 and maximum value is 30.

Comparison of Memory load and information visualization

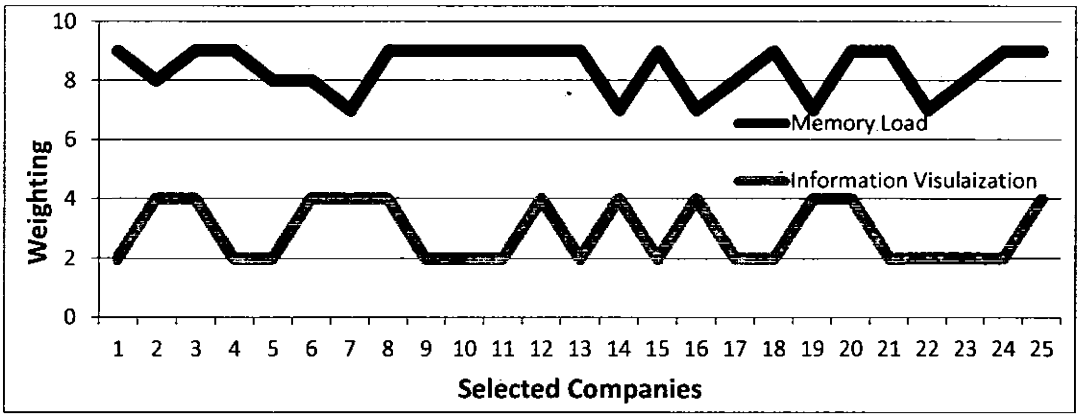

Figure 25

High Memory load and low support of information visualization leads to high memory load which is explained in the above graph. Mean value for memory load is 8.40, maximum value is 9 max and minimum value is 7. On other hand the figure of Information visualization mean is 2.88, maximum value is 4 and minimum value is 2.

Memory load and comparison of certification/standard compliances

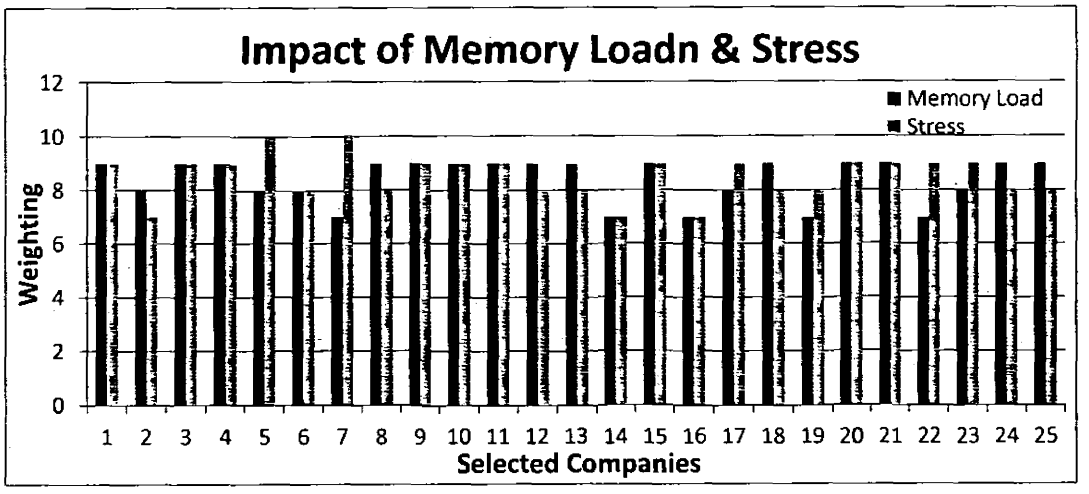

Figure 26

Increase in memory load and impact of stress are going side by side as presented in the above pictorial evidence. Memory load mean value is 8.40, 9 is maximum value and minimum value is 7. Moreover amount of mean stress is 8.52, maximum stress is 10 and minimum value is 7. Therefore both values are going towards increase almost at same rate. So it is concluded that higher memory load and higher amount of stress both are leading to increase cognitive load in the decision making process which is responsible to decrease the quality of decision making.

Comparison of support of standard/certificates and their compliances

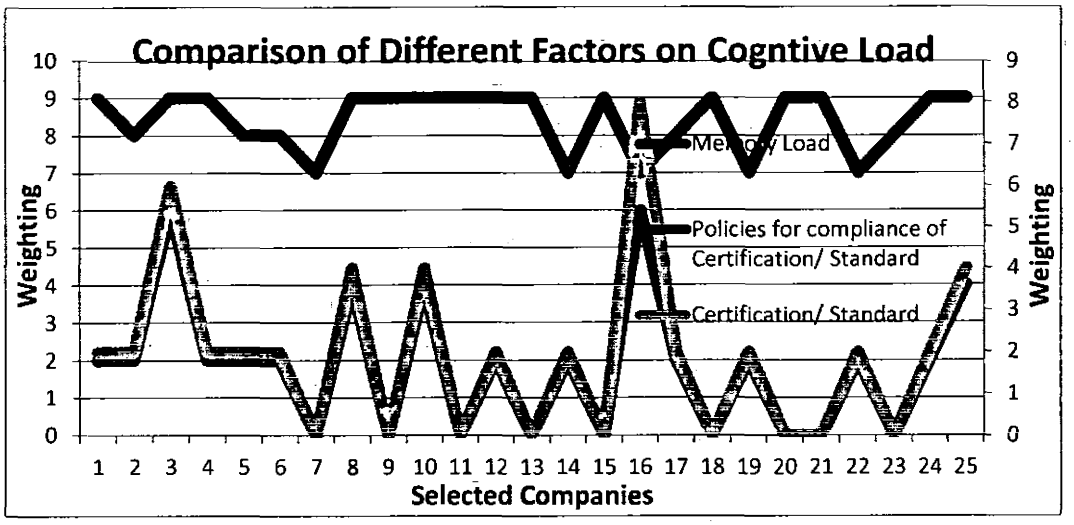

Figure 27

Increase in memory load is one of the major reasons for not complaining policies for compliances if certificating and access of certification to improve quality of work in software industry. Memory load value is very high as compare to two other factors which is 8.40 as a mean, 9 as maximum value and 7 as minimum value. Policies compliances mean value is 1.84, maximum range is 6 and minimum value is 0. Moreover Certification mean value is 1.92, maximum value is 8 and minimum value is 0. Result collected from industry are indicating that most of the organization neither acquiring certification/standards nor following policies to compliance these standards.

Organization and Compliance of Policies

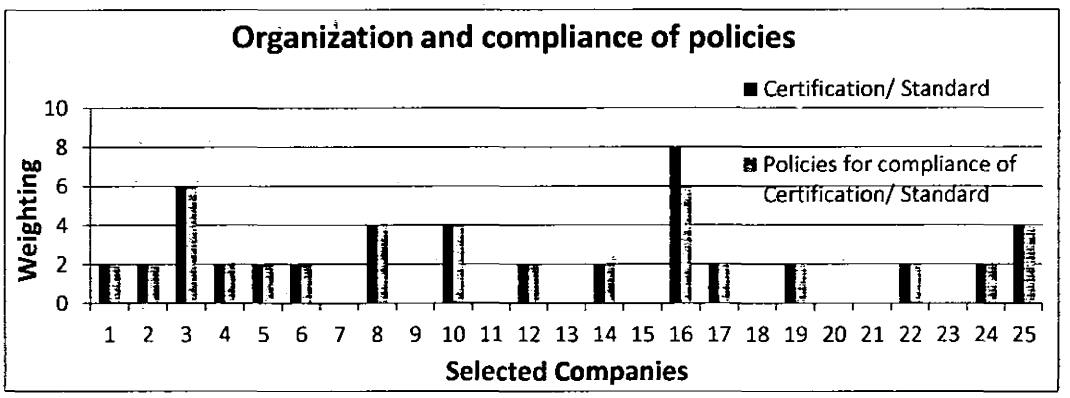

Figure 28

The above graph is reflecting the poor trend of attaining and following industry standards for software development. Policies compliances mean value is just 1.84, maximum value is 6 and minimum value is 0. Similarly Certification mean figure is jst1.92, maximum value pointed by experts is 8 and minimum value is 0. The picture presented in the above graph is showing the trend of low adoption of industry standards which is one of the major causes towards quality of decision making in requirements engineering.

Use of Re tools and their help in reducing load

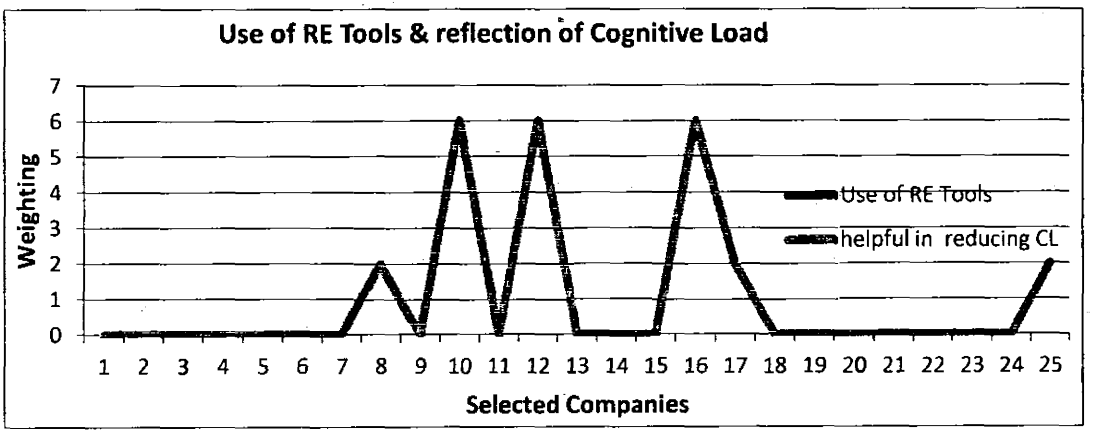

Figure 29

The above graph is showing the use of RE tools in software industry and its reflection on reduction of cognitive load during decision making process for improved quality of decision making. Use of re tools mean value is only 0.96, maximum value is 6 and minimum value is 0. Furthermore mean value for Reduction of Cognitive load is 0.96, maximum value is 6 and minimum value is 0

Comparison or RE tools use different Projects

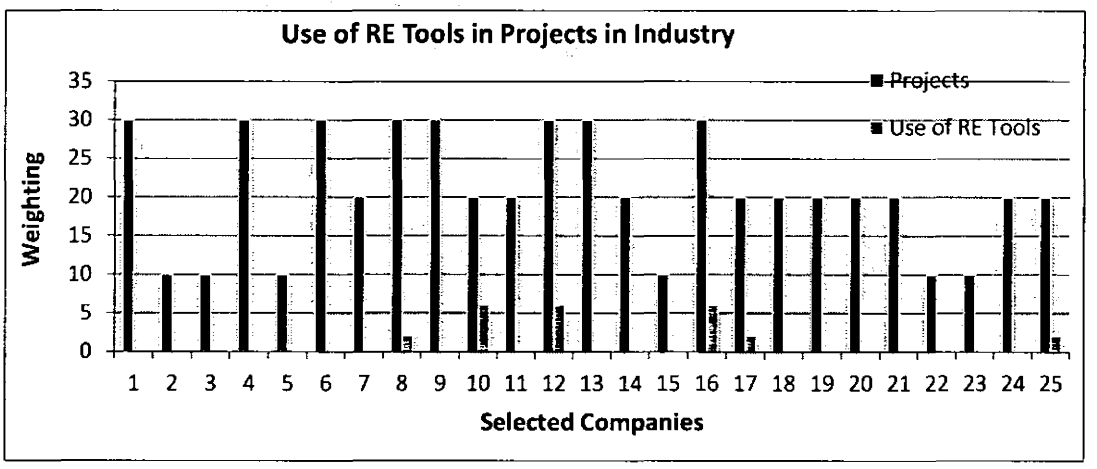

Figure 30

Here is the comparison of no of projects completed and the use of RE tools to manage requirements as part of requirements management. Mean data of projects 20.80, max value is 30 and minimum value is 10. In contrast use of RE tools is very low and having mean value of 0.96, maximum value is only 6 and minimum value is 0. The lesser the use of RE tools to manage projects requirements leading to reduced quality of decision making in requirements engineering decision support system.

Comparison of use of RE tools and training support

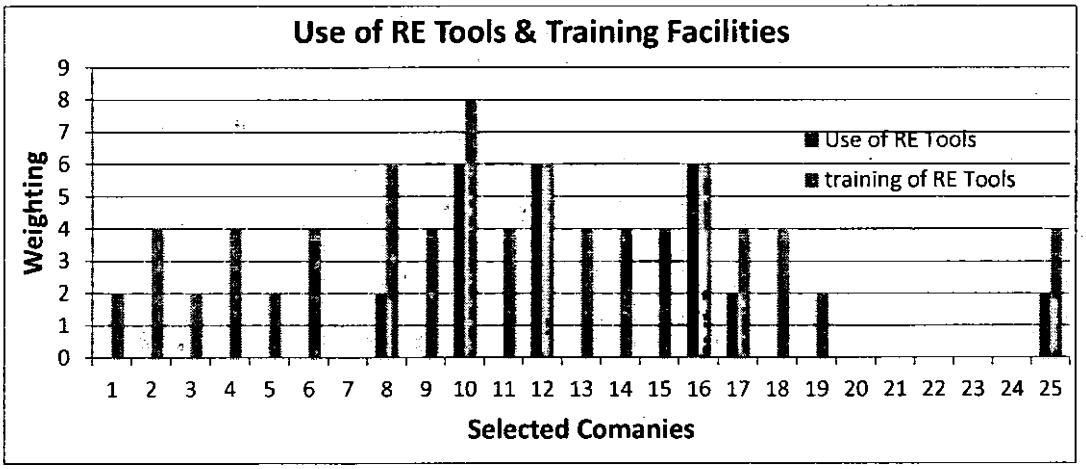

Figure 31

Use of RE tools and its success is directly depending on the chances of opportunities of training for the experts. More training facilities motivate experts for the use of tool. In the view of above graph it is concluded that training session are held but were not for profession requirements engineering tools. Statistics are indicating mean value for use of RE tools is 0.96, maximum value is 6 and similarly minimum value is nothing. Moreover mean value for training opportunities are 3.12, and overall values are ranging from 0 to 8.

Comparison of different aspect with reference to RE tools

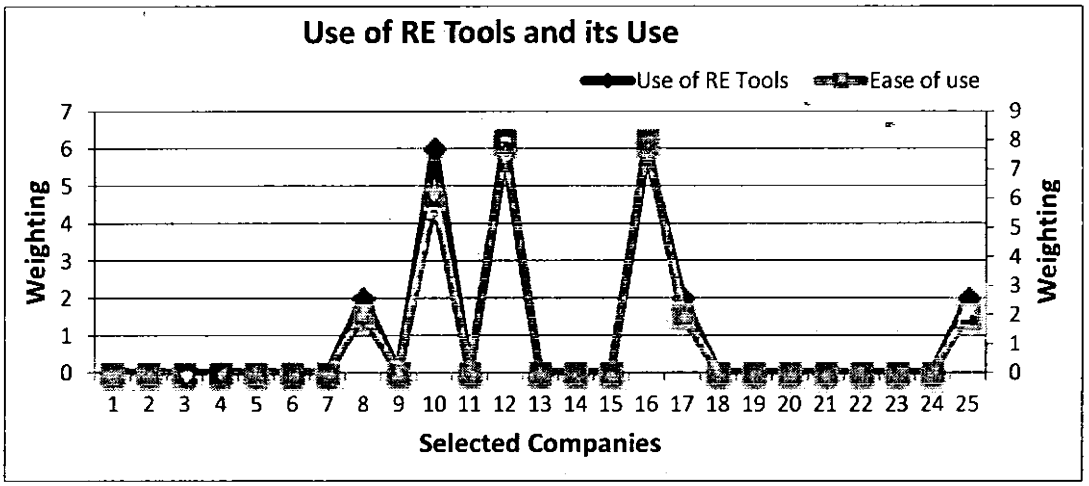

Figure 32

Comparison between use of RE tools and their ease of used is given in the above graph. Values for both use and its easiness are fluctuating at the same rate. Use of RE tools means figure is 0.96, maximum value is 6 and minimum value is 0. In contrast mean value for ease of use is 1.12, maximum value is 8 and minimum value is 0

Comparison of understanding, memory load and stress on project

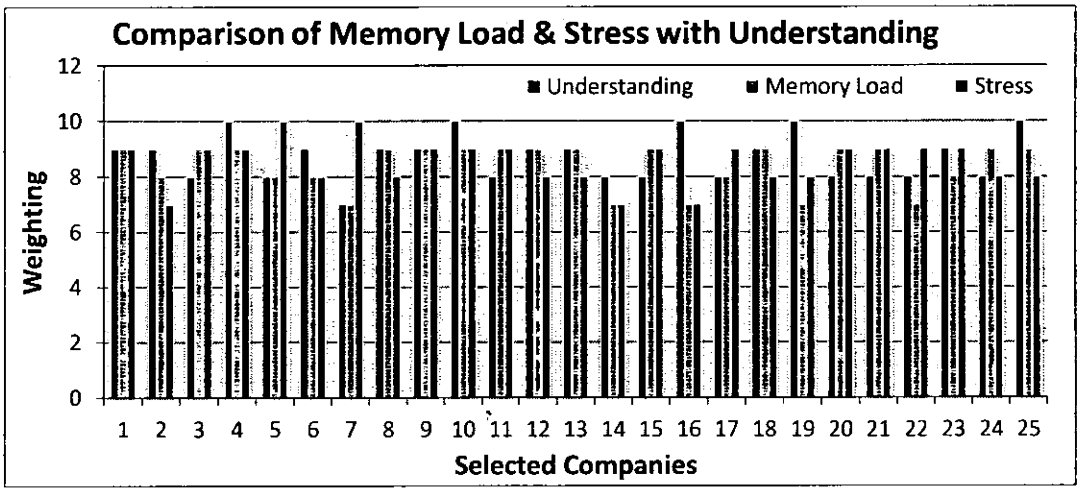

Figure 33

Understanding for the domain of requirement engineering domain mean value is 8.72, maximum value is 10 and minimum value is 7 which are reflecting that most of the experts are well informed about the area. Accordingly Memory load mean value is 8.40, maximum value is 9 and minimum value is 7. Another strong factor which is increasing cognitive load during requirements engineering decision support system is stress on experts during decision making process, the mean figure for stress level is 8.52, maximum value is 10 and minimum value is 7.

Comparison of Visual support for reduction of cognitive load

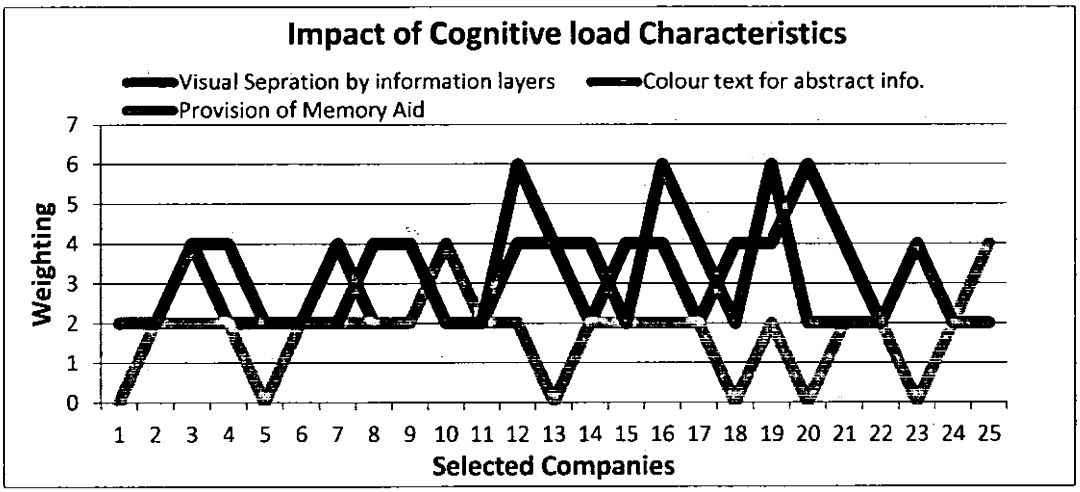

Figure 34

Chapter # 7

Conclusion

CONCLUSIONS

1. The empirical evidence concludes that the reduction of cognition load improves quality of decision making in Requirements Engineering?
2. It is further comes to view that the presentation of the factors required for reduction of cognitive load are very subjective in nature and their representation in RE tools needs further investigation in the social sciences domain
3. Empirical results also suggest that mere knowledge of cognitive load management is nonexistent and training in this area is necessary.
4. It is also shocking to bring to notice that no Requirement Engineering tool is being used in the industry and knowledge of requirement management practices is also missing with most of the practitioners.

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Annexure - I

Questionnaire

Organization:_____ **Experience:** _____

Q1. What is your role in software development industry?

1. Software Engineer
2. Software Developer
3. Project Manager
4. System Analyst

Q2. Encircle your total job experience.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24+

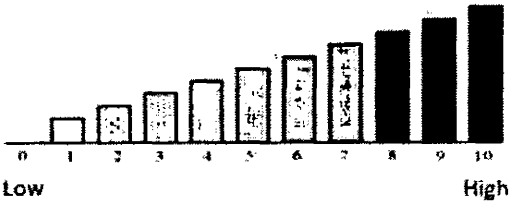
Q3. What is your experience specific to Requirements Engineering?

1 2 3 4 5 6 7 8 9 10 11 12+

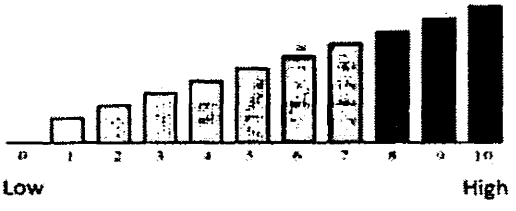
Q4. Encircle how many software projects you have completed so far?

10 20 30 40 50+

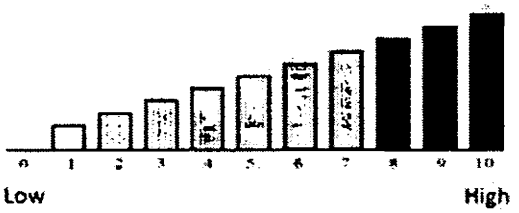
Q5. At which rate do you scale that lack of understanding of Requirements Engineering field makes decision making difficult in Requirement Engineering?



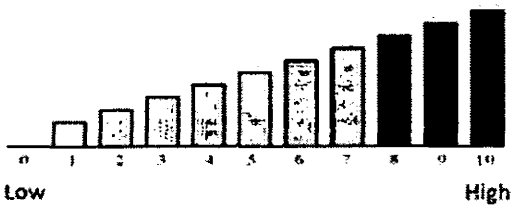
Q6. How do you rate the level of clarity about general overview of project requirements?



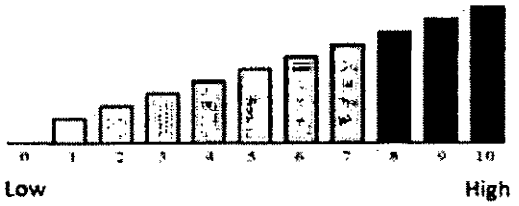
Q7. Do you suffer from High memory load during requirements decision making?



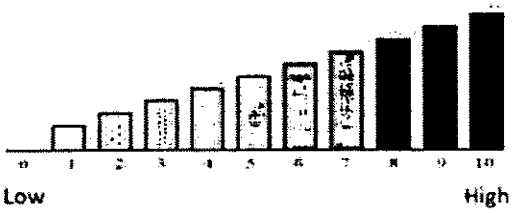
Q8. How do you rate the understanding of the goal specific tasks?



Q9. How do you rate the stress during your work hours?



Q10. What is the impact of redundancy of requirements?



Q11. Do you possess good understanding of the cognitive load?

a) Strongly Disagree
b) Disagree
c) Undecided
d) Agree
e) Strongly Agree

Q12. Have you defined policies and procedures for requirements management in order to reduce the impact of cognitive load?

a) Strongly Disagree
b) Disagree
c) Undecided
d) Agree
e) Strongly Agree

Q13. Is there sufficient staff during requirements phase in your organization in order to reduce the impact of cognitive load?

a) Strongly Disagree
b) Disagree
c) Undecided
d) Agree
e) Strongly Agree

Q14. Do you think time factor as a major cause of increase of cognitive load?

a) Strongly Disagree
b) Disagree
c) Undecided
d) Agree
e) Strongly Agree

Q15. Do you think the change in the policies and procedures of the requirements management is carried out quickly without an issue of cognitive load?

a) Strongly Disagree
b) Disagree
c) Undecided
d) Agree
e) Strongly Agree

Q16. Do you use Requirement Engineering tool(s) in order to manage the cognitive load?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q17. At which extent RE tool(s) are helpful in solving the plight of cognitive load?

a) Not Applicable
b) Unknown
c) Low

d) Very Low
e) Average
f) High
g) Very High

Q18. Is it easy to use the tool(s) for RE decision making?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q19. Are you facilitated with the training of RE tool(s)?

a) Strongly Disagree
b) Disagree
c) Undecided
d) Agree
e) Strongly Agree

Q20.During RE decision making the information provided to you is visualized or not?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q21. Do you use/consider design strategies during use of RE Tools?

a) Not Applicable
b) Unknown
c) Low

d) Very Low
e) Average
f) High
g) Very High

Q22. Do you add complete details of information for better comprehension?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q23. Do you visually separate the different data types in order to create information layers?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q24. Do you compare data for RE differences to compare changes within data?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q25. Do you use colored text for abstract information?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q26. Is memory aid provided during RE decision making process?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q27. Does project feasibility helps in memory aid?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q28. Do political factors influence the requirement management process and are the cause of stress or memory load?

a) Not Applicable
b) Unknown
c) Low
d) Very Low

e) Average
f) High
g) Very High

Q29. Do you think that use case scenarios help in managing and implementing software requirements?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q30. Does reusability of requirements of other systems helps in reducing cognitive load?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q31. Do you use prototypes in managing software requirements?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q32. Is system boundary defined properly during requirements analysis phase?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q33. Do you use check lists in requirements analysis phase in order to manage memory load?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q34. How do you rate the efficiency of your organization to resolve the conflicts?

Q35. Do you perform requirements prioritization in order to reduce the impact of cognitive load?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q36. At which level the risk management affects the cognitive load?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q37. Does standardization of the documents help in managing memory load?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q38. Does multidisciplinary teams are used in order to review the software requirements?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q39. Are validation checklist used to validate the requirements?

a) Not Applicable
b) Unknown
c) Low
d) Very Low

e) Average
f) High
g) Very High

Q40. Do you use prototyping for requirements validation?
a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q41. Do you use test cases for validation of your requirements?
a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q42. Do stakeholders validate the requirements?
a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q43. Do you perform requirements traceability in an efficient way?
a) Not Applicable
b) Unknown

c) Low
d) Very Low
e) Average
f) High
g) Very High

Q44. Is it easy to manage volatile requirements?
a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q45. Do you plan to manage the rejected requirements?
a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q46. Do you define policies to manage the rejected requirements?
h) Not Applicable
i) Unknown
j) Low
k) Very Low
l) Average
m) High
n) Very High

Q47. Do you define policies to manage the volatile requirements?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q48. Do stakeholders involve in all stages i.e. from requirements elicitation to requirements validation?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q49. Is your organization certified as per industry standards?

a) Not Applicable
b) Unknown
c) Low
d) Very Low
e) Average
f) High
g) Very High

Q50. Are your policies in compliance to your organization's certification?

a) Not Applicable
b) Unknown
c) Low
d) Very Low

e) Average

f) High

g) Very High

Annexure – II

PROJECT 1 ONLINE CAR SHOWROOM

Functional Requirements:

General:

1. The user shall be able to login to system.
2. The user shall be able to logout from system.
3. The user shall be able to change his/her password.
4. The user shall be able to change his/her password.
5. The user shall be able to update details of new/used car model.
6. The user shall be able to view new/used car model information.
7. The user shall be able to delete car information.

Rent a Car Management:

8. The user shall be able to rent a car.
9. The user shall be able to update details of rent a car.
10. The user shall be able to view rent a car information.
11. The user shall be able to delete rent a car information.

Sell a Car Management:

12. The user shall be able to sell a car.
13. The user shall be able to update details of sell a car.
14. The user shall be able to view sell a car information.
15. The user shall be able to delete sell a car information.

Buy a Car Management:

16. The user shall be able to buy a car.
17. The user shall be able to update the details of buy a car.
18. The user shall be able to view buy a car information.
19. The user shall be able to delete buy a car information.

Auto-shops Information Management:

20. The user shall be able to add auto-shops information.
21. The user shall be able to update the details of auto-shops information.
22. The user shall be able to view the auto-shops information.
23. The user shall be able to delete the auto-shops information.

Personal Account Management:

24. The user shall be able to update details of his/her account.
25. The user shall be able to view his/her account information.

Advertisement Management:

26. The user shall be able to upload an advertisement.
27. The user shall be able to update details of advertisement.
28. The user shall be able to view his/her advertisement.
29. The user shall be able to delete his/her advertisement.

Rate and Review Management:

30. The user shall be able to add rate and review.
31. The user shall be able to update his/her rate and review.
32. The user shall be able to view his/her rate and review.
33. The user shall be able to delete rate and review.

User Improvement Management:

34. The user shall be able to add ask query information about any car model.
35. The user shall be able to add buying advice information.
36. The user shall be able to view ask query information.
37. The user shall be able to view buying advice information.
38. The user shall be able to delete ask query information.
39. The user shall be able to delete buying advice information.

Search Management:

40. The user shall be able to search an advertisement.

41. The user shall be able to search new car information.
42. The user shall be able to search used car information.

Administrator Management:

43. The user shall be able to create an account.
44. The user shall be able to add records.
45. The user shall be able to update records.
46. The user shall be able to view records.
47. The user shall be able to delete records.
48. The user shall be able to view other user's information.
49. The user shall be able to create new account.
50. The user shall be able to update other user accounts.
51. The user shall be able to delete other user accounts.

PROJECT 2 ONLINE Evaluation and Management System

52. Add new page dynamically.
53. Delete existing page.
54. Edit/Update a page.
55. Add useful Quick Links on front end website.
56. Delete Quick Links on demand.
57. Edit/Update Quick Links when required.
58. Upload images/pictures to gallery folder.
59. Delete images from server on request.
60. View feedback coming from public users and parents of students.
61. Reply to feedbacks in the form of email.
62. Add news/events about organization on front end website.
63. Edit/update existing news on demand.
64. Delete news from news folder on demand.
65. Add new user to the system.
66. Activate/deactivate user accounts.
67. Delete users when required.

68. Register new students.
69. Make automatic fee due on incoming students.
70. Make monthly fee due on all students on request.
71. Make transport fee due if required.
72. Fee submission.
73. Fine submission.
74. Classes and courses association.
75. Add new class.
76. Add new section.
77. Add new course.
78. Add new teacher.
79. Teacher and courses association.
80. Fine students.
81. Test/Assign management.
82. List of outstanding dues of students.

Administrator Management:

83. The user shall be able to login to the system.
84. The user shall be able to add new users.
85. The user shall be able to update user information.
86. The user shall be able to delete existing users.
87. The user shall be able to assign roles to the users.
88. The user shall be able to add dynamic pages.
89. The user shall be able to update the already existing pages.
90. The user shall be able to delete the expire pages.
91. The user shall be able to add news.
92. The user shall be able to update news.
93. The user shall be able to delete news.
94. The user shall be able to logout.

Staff/Clerk Management:

95. The user shall be able to login to the system.

96. The user shall be able to register students.
97. The user shall be able to edit/update students.
98. The user shall be able to add a new class.
99. The user shall be able to edit/update and delete the already existing classes.
100. The user shall be able to add new sections to the class.
101. The user shall be able to edit/update and delete the already existing section.
102. The user shall be able to add new courses.
103. The user shall be able to update or delete the existing courses.
104. The user shall be able to assign teachers to the course.
105. The user shall be able to increase or decrease the courses assigned to the teachers.
106. The user shall be able to design the fee structure for the class.
107. The user shall be able to edit/update or delete the existing fee structure.
108. The user shall be able to make the fee due on all of the students of the college.
109. The user shall be able to submit all kinds of fee.
110. The user shall be able to make a list of outstanding dues of students.
111. The user shall be able to enter the quizzes/Assigns.
112. The user shall be able to enter the exam marks.
113. The user shall be able to manage the attendance of the students.

PROJECT 3 Hajians Filling Station Management System (HFSMS)

114. The user must be authenticated user of the system and already have the right to login.
115. The user wants to assign user right of the system to the employees and owners of HFSMS.
116. The user wants of change the user rights to the system.
117. The user wants to add an employee.
118. The user wants to record new sale of the fuels (Super, Diesel) by entering reading from nozzle.
119. The user wants to edit/update the sale of the fuels (Super, Diesel) by editing reading of the nozzle on previous dates.

120. The user wants to change retail of the fuels (Super, Diesel) by editing reading of nozzle on previous dates.
121. The user wants to add the purchase for the products.
122. The user wants to add the transaction made against an account.
123. The user wants to update the transaction made against an account.
124. The user wants to add attendance of the employees.
125. The user wants to update attendance of the employees.
126. The user wants to view journal.
127. The user wants to view his/her account and share.

PROJECT 4 Paraplegic Management System (PPC)

128. The user wants to login to the system.
129. The user wants to assign user right of the system to the employees.
130. The user wants to add department to the system.
131. The user wants to add an employee to the department.
132. The user wants to define a new pay scale that will be implemented on incoming salaries.
133. The user wants to add a new patient bio-data record t his/her patient list.
134. The user wants to update an existing patient bio-data record in his/her patient list.
135. The user wants to view details of a patient bio-data record in his/her patient list.
136. The user wants to delete patient bio-data record in his/her patient list.
137. The user wants to add patient to the waiting list.
138. The user wants to view details of the waiting list patient.
139. .The user wants to delete a waiting patient from the waiting list.
140. The user wants to register a patient.
141. The user wants to update existing patient registration information in his/her registered patient list.
142. The user wants to view registered patient detail in the registered patient list.
143. The user wants to delete patient registration record in registered patient list.
144. The user wants to examine general checkup of a new registered patient.

145. The user wants to update an existing patient general checkup data.
146. The user wants to view detail of a patient general checkup.
147. The user wants to discharge a registered patient.
148. The user wants to examine neurological level of a registered patient.
149. The user wants to update an existing patient neurological level data.
150. The user wants to examine sensory assessment of a registered patient.
151. The user wants to update an existing patient sensory assessment data.
152. The user wants to delete patient sensory assessment.
153. The user wants to add a new category.
154. The user wants to add new item to existing category.
155. The user wants to generate a new purchase order of items against a specific category.
156. The user wants to purchase items of an order.
157. The user wants to view items in stock for a specific category.
158. The user wants to issue items of a specific category to the particular user, department or patient.
159. The user wants to record expenditure.
160. The user wants to generate a new sale order of items.
161. The user wants to sale items of an order.
162. The user wants to issue medicines to the particular patient, department or user.
163. The user wants to check the availability of items/medicines in the store.
164. The user wants to record/add x-ray information of a particular patient.
165. The user wants to record/add new blood test of a particular patient.
166. The user wants to record/add new surgery of a particular patient.
167. The user wants to add aid given by an organization.
168. The user wants to pay account payable of a particular category.
169. The user wants to pay salaries to employees.
170. The user wants to view the overall cash flow in the PPC.

PROJECT 5 Real Estate Management & Information System

171. A user wants to create an account on the website.
172. A dealer wants to create an account on the website.

173. An admin wants to register a dealer's account.
174. An admin wants to register another admin account on the website.
175. A user wants to add property either for sale or for rent.
176. A dealer wants to add property either for sale or for rent.
177. A user wants to find property for sale.
178. A dealer wants to find property for sale.
179. A system admin wants to find property for sale.
180. A user wants to view the list of property he wishes to buy or rent.
181. A dealer wants to view the list of property he wishes to buy or rent.
182. A user wants to find the details of a desirable property for sale.
183. A dealer wants to find the details of a desirable property for sale.
184. A system admin wants to find the details of a desirable property for sale.
185. A user wants to find wants the details of a desirable property for rent.
186. A dealer wants to find wants the details of a desirable property for rent.
187. A system admin wants to find wants the details of a desirable property for rent.
188. A user wants to find wants the details of a desirable property buyer.
189. A dealer wants to find wants the details of a desirable property buyer.
190. A system admin wants to find wants the details of a desirable property buyer.
191. A user wants to find wants the details of desirable property rentals.
192. A dealer wants to find wants the details of desirable property rentals.
193. A system admin wants to find wants the details of desirable property rentals.
194. A general user wants to view property dealers or agents.
195. A property dealer wants to view property dealer or agents.
196. An admin wants to view property dealers or agents.
197. A general user wants to update his/her profile on the website.
198. A dealer wants to update his profile on the website.
199. Administrator wants to update his profile on the website.
200. A general user wants to change his/her account password.
201. A dealer wants to change his account password.
202. Administrator wants to change his account password.
203. A general user wants to recover his/her account password.

204. A dealer wants to recover his account password.
205. Administrator wants to recover his account password.
206. Moderator wants to delete User, Dealer or Administrator account.
207. Administrator wants to delete dealer account or general user account.
208. Dealer wants to delete general user account.

PROJECT 6 Clinical Laboratory Management System

Administrator:

209. Administrator wants to manage user record in an accurate way.
210. Administrator is interested in handling payments.
211. Administrator wants to prevent losses of business due to theft or loss of items.
212. Administrator wants to control inventory system and prevent theft or loss of items.
213. Administrator wants to manage patient's medical report in an accurate way.
214. Administrator wants to manage all kind of tests done in clinical laboratory in an accurate way.
215. Administrator wants to mange test result in an accurate way.
216. Administrator wants smooth running of clinic and desire increase in beneficial clinic transaction.
217. Administrator wants to register patients to have their records in the system.
218. Administrator wants to manage tests not done in this laboratory.
219. Administrator wants to manage some policies for well management of the clinic.

Sales Person:

220. Sales person wants to handle payments in an accurate and easy way.
221. Sales person wants up to date information of each item and ensures that the item is available which is needed by the customer.
222. Sales person wants accurate, complete and up to date information of the medicine and other medical products.

Patient:

223. Patient wants to make payment in a fast way and interested in having record of his payment.
224. Patient wants to have accurate medical reports.
225. Patient wants to have his test result done very correctly.
226. Patient wants the medicine and other products to be available in shelf all the time.
227. Patient wants to have his record in the system and to be a registered patient of the clinic.
228. Patient wants to have remote test processing to save his time.

Laboratory Technician:

229. Laboratory technician wants to prepare accurate reports required by administrator, patient, and doctor.
230. Laboratory technician wants to calculate test results.
231. Laboratory technician wants to send tests to other laboratories not done in this lab.

Business:

232. Ensure the availability of almost all kinds of medicines and instruments.
233. Ensure the management of business policies for good results.

PROJECT 7 Student Project Management System

Student:

234. Student wants to register, to use the Student Project Management System to see/search the available projects.
235. Student wants to download the projects.
236. Student wants to use the services and features.
237. Student wants to sign out from the application.
238. Student wants to update his/her profile and to stay updated with the system.
239. Student wants to change his password so that the user account is kept secure.
240. Student wants to apply for a job.
241. Student wants to view the details of a job.

242. Student wants to add/post comments on the system.
243. Student wants to view date-sheet.

Teacher:

244. Teacher wants to register, to use the Student Project Management System to see the record of students and projects.
245. Teacher wants to search projects.
246. Teacher wants to download projects.
247. Teacher wants to add/post comments on the system.

Admin:

248. Admin wants to add student.
249. Admin wants to add and upload the project.
250. Admin wants to delete a form.
251. Admin wants to add a teacher.
252. Admin wants to add a job.
253. Admin wants to delete a job.
254. Admin wants to view a job.
255. Admin wants to add date-sheet.
256. Admin wants to change date-sheet.
257. Admin wants to delete date-sheet.
258. Admin wants to remove user account.

PROJECT 8 AV Alaunched An Information and Entertainment System

Video Section:

259. The user shall be able to view video by category.
260. The user shall be able to search a video by title.
261. The user shall be able to upload a desired video.
262. The user shall be able to write comments on video.

263. The user shall be able to invite friends to see the video.
264. The user (administrator) shall be able to delete a video.
265. The user (administrator) shall be able to delete comments.

Audio Section:

266. The user shall be able to cerate album.
267. The user shall be able to view album.
268. The user shall be able to search an album by title.
269. The user shall be able to upload an album.
270. The user (administrator) shall be authorized to delete any album.

EBooks:

271. The user shall be able to view books by category.
272. The user shall be able to upload the books by desired category.
273. The user shall be able to search books by title.
274. The user shall be able to write comments on books.
275. The user shall be able to invite friends to read the books.
276. The user shall be able to read books online.
277. The user (administrator) shall be authorized to delete any book.
278. The user (administrator) shall be authorized to delete any comment.

Chat Room:

279. The user (administrator) shall be able to create a chat room.
280. The user shall be able to join a chat room.
281. The user (administrator) shall be able to delete any room.
282. The user shall be able to do public chat where there will be no privacy.
283. The user shall be able to send private messages to other users.

Software Downloads:

284. The user shall be able to view software.
285. The user shall be able to upload software.
286. The user (administrator) shall be able to delete any software.
287. The user shall be able to download software.

Online Games:

288. The user shall be able to view the games.
289. The user shall be able to upload the games.
290. The user shall be able to play online games.
291. The user (administrator) shall be able to delete any game.

User Management:

292. System shall provide a login page as a startup page.
293. The user shall be able to login to system.
294. The user shall be able to create his/her account.
295. The user shall be able to logout from the system.
296. The user shall be able to modify his/her profile.
297. The user shall be able to change his/her password.
298. Upon changing password an automated email should be sent to that user.
299. The user shall be able to recover his/her user name.
300. The user shall be able to recover his/her password name.

PROJECT 9 Hardware Store Management System (HSMS)

Customer:

301. Customer wants to login to the system.
302. Customer wants to change his/her password.
303. Customer wants to logout from the system.
304. Customer wants to view the products.
305. Customer wants to place an order.
306. Customer wants to edit an order.
307. Customer wants to view his/her orders.
308. Customer wants to cancel an order.

Admin:

309. Admin wants to add employees.
310. Admin wants data editing/updating of profiles of employees.

311. Admin wants to view employee details.
312. Admin wants to suspend the account of an employee.
313. Admin wants to activate the account of an employee.
314. Admin wants to manage the orders revoked by the employees.
315. Admin wants to view the data of the customers.
316. Admin wants to update customer data.
317. Admin wants to view orders placed by the customers.
318. Admin wants to suspend the accounts of customers.
319. Admin wants to activate the accounts of customers.
320. Admin wants to deactivate the account of a customer.
321. Admin wants to update the profile of the customer.
322. Admin wants to add new vendors.
323. Admin wants to update the profile of vendors.
324. Admin wants to view the vendors.
325. Admin wants to pay the vendors.
326. Admin wants to add the products.
327. Admin wants to edit the products.
328. Admin wants to view the products.
329. Admin wants discontinuation of the products.
330. Admin wants to add stock.
331. Admin wants to delete stock.
332. Admin wants to add rates of the products.
333. Admin wants to view the orders placed by the customers.
334. Admin wants to hide orders.
335. Admin wants to add ranks.
336. Admin wants to edit ranks.
337. Admin wants to delete ranks.
338. Admin wants to add location.
339. Admin wants to edit location.
340. Admin wants to delete a location.
341. Admin wants to add an area.
342. Admin wants to edit an area.

343. Admin wants to delete an area.
344. Admin wants to add a category.
345. Admin wants to edit a category.
346. Admin wants to delete a category.
347. Admin wants to view user log/user report.
348. Admin wants to view product log/product report.
349. Admin wants to view order log.
350. Admin wants to view the attendance of employees.
351. Admin wants to process the payments to employees.

Employee:

352. Employee wants to view his/her salary receipt.
353. Employee wants to view orders.
354. Employee wants to process an order.
355. Employee wants to hide orders.

PROJECT 10 Nadempiere CRM

356. System will be able to add an employee.
357. System will be able to update an employee.
358. System will be able to delete an employee.
359. System will be able to maintain the timecard.
360. System will be able to manage the payroll.
361. System will be able to maintain status of the employees.
362. System will be able to maintain the attendance of the employees.
363. System will be able to delete an employee.
364. The system will be able to create a purchase order.
365. The system will be able to update a purchase order.
366. The system will be able to delete a purchase order.
367. System will be able to add a project.
368. System will be able to update a project.
369. System will be able to delete a project.
370. The system will be able to advertise a job.

371. The system will be able to hire an employee.
372. The system will be able to create a user log or report.
373. The system will be able to create an employee report.
374. System will be able to create a bill.
375. System will be able to update a bill.
376. System will be able to delete a bill.
377. System will be able to add a product.
378. System will be able to update a product.
379. System will be able to delete a product.
380. System will be able to create a service.
381. System will be able to update a service.
382. System will be able to delete a service.
383. System will be able to record the calls and mails.
384. System will be able to add complaints of the customers.
385. System will allow the customer to evaluate the employee.