Cognitive Approach to Root Cause Analysis for Improving Quality of life: A case study for IT Industry

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Abstract
Software Industries become one of the leading industries now days. With the objective of producing best quality of software, testing is one of technique to judge the quality and the reliability of the software. Since prevention is always better than the cure, so testing must be supplemented with root cause analysis (RCA). The goal is to identify the root cause of defect and initiate actions so that the source of defect can be eliminated. The qualitative analysis provides feedback to quality manager that eventually improve both quality and the productivity of the software organization. When RCA is analyzed with cognitive parameters, it helps to improve the job satisfaction component among the employee thereby increasing the product quality as well as quality of life. This paper aims with such objective. Various errors that are generated during SDCL are classified and organized as per RCA applicable to IT industry. RCA are further defined with respect to cognitive science.

Key Words: Root Cause Analysis (RCA), SDLC (Software Development Life Cycle), Defects, Testing, Human Reliability, Human Error

1 Introduction
Today the competition to produce the superior quality of product gets boost up. As software is the core element of every product, the demand of quality software has also increased. With the objective of producing best quality of software, testing is the one of technique to judge the quality and the reliability of the software. There are many tools available which are used for investigating and reporting the causes of defect. Depending upon the cause, one can correct or prevent errors. Defect prevention, and defect mitigation strategies will help to reduce the rate of defects in software systems [1]. Defect cause factors can be classified as direct cause, contributing cause and root cause. The root cause usually has generic implications to a large cluster of possible error occurrences, which can logically be identified and corrected. In Human Computer Interaction (HCI), a domain where cognitive sciences are involved, the study of human behaviors has proven to be rewarding. The domain of study of human behavior in software engineering has been called “psychology of programming” [2]. Cognitive science is the investigation of human cognition, that is, human mental capability – perceiving, remembering, learning, opinion, reasoning, and understanding.

Since all software’s are developed by human begin, so nobody can neglect the human reliability and errors & mistake done by them. Human factors have taken on a significant role within the software engineering [8]. Human error in system can be introduced at any phase of SPE (Software Process Engineering); accordingly they are classified as:
1. **Requirements or Specification errors:** The picture of intended outcome of software is depending on the information acquired requirement of the functions. The errors can be caused by an incomplete or ambiguous requirement or by communication gap.

2. **Design Error:** The designs may differ from the stated requirements or are ambiguous or carry incomplete assumptions, thereby causing errors.

3. **Code Error:** Such type errors are introduced during coding due to syntactic or structural errors or due to difference in documented design or requirements.

4. **Test Error:** These types of errors originate due to incorrect test designs with respect to stated requirements, designs or test cases. They may be due to incorrect execution of test case or incorrect interpretation of the resultant output by the tester, leading to “logged in error”.

Whatever the kinds of errors are, its root cause has to be analyzed so as to eliminate the occurrence of errors forever. RCA expect that systems and events are interrelated. An action in one part initializes an action in another, and another, and so on. By tracing back these actions, it can be found out where the problem started and how it grew into the warning sign that user is facing now. To attain maximum efficiency, the Root Cause Analysis should be performed instantly following the event occurrence. The investigation facts are focused to discover, in a value-neutral manner, that show how an incident occurred, what actually happened and why an incident occurred. This is done by placing the simply factual representation of the event within the context of the IT system to compare what actually happened against what should have happened, at any position during the incident.

Root cause analyses still relies heavily on persona; experience and expertise, but employing formal techniques proves to users and executives that the root cause, not just a cause has been discovered and also fixed it so that incident will not reoccurs[3].

Some of the RCA tools which work successful in IT industries are Fault Tree Analysis (FTA)[5], Events and Causal Factors Charting[5], Brain Storming Brain Writing[5], Nominal Group Technique[5], Five Why’s[5], Fishbone Diagrams / Cause and Effect Chart’s[5], Genetic Root Cause Analysis[6] and Root Cause Analysis For Long-lived TCP Connections[7] etc.

![Figure 1 The life cycle of root cause analysis](image-url)

All RCA techniques include the following basic steps:

1. **Investigation Phase**
2. **Analysis Phase**
3. **Decision Phase**
4. **Communication Phase**
5. **Implementation Phase**

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• Identify the problem and its impact that is investigation phase.
• Identify the causes (conditions or actions) immediately prior and adjoining the problem that is analysis phase.
• Identify the source why the causes in the preceding step existed, working back to the root cause (the final point in the analysis phase).
• Identify actions and lessons learned to correct or eliminate the root causes of incident, in order to achieve long-term, effective results and acquire high quality of the software (decision, communication and implementation phase).

The life cycle of root cause analysis can be depicted as in fig I

2 Human Performance and related work
In order to maximize influence on user interface development, various approaches have been used for managing human factors resources. Some of them are: hiring human factors engineers or psychologists directly into development teams; concentrating human factors engineers in a support organization; making use of external consultants with user interface knowledge; placing a development group under the leadership of a human factors professional; and forming an educational center in which software engineers learn about human factors approaches [8]. Knowledge and the skill are important human factor to achieve best results, although humans are often at the core of a problem, they are crucially part of the solution [9]. Although knowledge and skill can be improved through proper training but there are number of factors on which human performance depends like working environment, age, experience, gender behavioral differences, emotion, perception, and personality, decision-making, cognition, fatigue, stress etc.

According to David [10], slips and lapses, mistakes and violations are the major reasons for errors occurrence. (a) Slips and Lapses are skill based errors that occur in very familiar tasks which can carry out without much need for conscious attention. Failures in carrying out the actions of a task causes slips while Lapse of memory leads to forcedness for carrying out an action or to drop something in a task or even fail to remember what one is intended to do. (b) Mistakes mean doing wrong things while believing it to be right. So they are more complex type of errors done by humans begins. There are two types of mistakes that exist, rule-based and knowledge-based. Rule-based mistakes can be occurs when person’s behavior is based on remembering rules or familiar procedures. Human begin have a strong tendency to use familiar rules or solutions even when these are not the most suitable, easy or efficient. Knowledge-based mistakes are improvisation in unfamiliar environments and no routines or rules available for handling such situation [11]. (c) Violations are intentional deviations from rules, procedures, instructions and regulations. They can be routine violations that occur when breaking a rule or procedure has become a normal way of working within a group. Situational violations occur due to time or workload pressures, the wrong equipment being available or other situation-specific factors such as weather. Exceptional violations only happen when something has gone wrong and to address the problem rule breaking is considered ‘worth the risk’.

There are some vital features that affect to recover the human errors like knowledge; communication, quality conscious, calm and cool, speed of work and productivity, open minded and updated, attention, stamina and concentration, self-motivated and enthusiastic [12].

The analysis of the human reliability will help to improve the quality of the product under development as well as will helps the individuals to choose a right job. It will also help human resource managers to

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choose appropriate team members for a particular task in particular condition which reduces the root errors to yield a good productive team. All these can be illustrated through following case study.

3 Proposed Root cause defects for human errors
There are many causes behind the occurrence of these errors. These errors can be classified in to different levels i.e. Technical errors, Organizational errors, Infrastructural or Human error [13]. In this paper Root cause analysis is done on human errors with respect to their behavior. The main root cause defects are classified as omission, lack of knowledge, miscommunication, accidental, transcription, process gap and time shortage. These root causes are further analyzed through cognitive approach of error development. Some of the parameters that were analyzed through this study are as follows:

- Carelessness/ ignorance:- Carelessness or Ignorance is one of the major behavior key of humans that effects the quality of the software development process. People tend to ignore the rules and do slips or mistakes thereby creating probability of error occurrence. Ignoring minor errors at initial stage are converted to defects later on. Such types of errors may be treated as root cause for omission errors or process gap.

- Perfectionism:- Perfection is one of the key of success in time bound software development. People lacking in this nature will have to do lot of rework during software development and testing process. Such type of errors may be categorized as root cause for lack of knowledge or time shortage. In order to improve on this quality there is a need for training to improve their skill. Such an effort will also boost the personal confidence of employee.

- Reserve Personality: There are certain stages during SDLC that needs interaction with other people. Reserve or introvert persons may not be comfortable in discussion with other people. There might be also some language incompatibility in team member. All these may lead to miscommunication.

- Attitude of personality:- Approach to do work is also responsible on attitude of persons behavior and compatibility with system provided. Accidental errors are generated due to failure of software/hardware infrastructural or by violent or negative attitude persons.

- Dominance & less vigilance personality:- Persons having dominance in nature and lack of attention about the outcome, yields root cause as transcription or omission. These types of error are due to undeclared or communication gap between team works and organization.

- Emotional Stability factor:- Human behavior is also influences by people working around them, environment and state of their mind. Many errors are caused due to mismanagement of time and schedules, which increases the work pressure and shortage of time.

4 Case Study
Aim of study is to understand the different type of errors cause by individual and their root cause of occurrence with respect to cognitive analysis.

The conditions for the case study are:
1. Case study was done under normal conditions.
2. Questionnaire form given to developing team member to fill only those phase of SPE for which they had worked.
3. Sample data consists of the following characteristics:
   a. Mixed gender

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b. Having Age < 40
The case study is being done by filling questionnaire form either for software developer or by software testers. The results were compiled on the behalf of data collected through forms filled by employee. They filled the form according to errors faced by them during the developing and testing phases of SPE.

5 Analysis
This study is done on software developing and testing team members of IT Companies, from which 65% are male and 35% are female. The table1 shows the probability of percentage of total error occurred per person, per male or female during SDLC / development phase/ testing phase; according to defect cause. Fig1 is the graphically representation of table1. According to the data it shows that the maximum number of errors occurs 81.92% is due to defect D2 which is lack of knowledge and minimum error 25.02% is due to defect D5 which is transcription. While comparing the data on gender basis it is found that lack of knowledge is the main cause for maximum errors for both the genders.

5.1 Development Phase
Development phase consists of many sub phases. In this phase the errors so generated either in totality or by males or by females are very less. Time bound projects have minimum errors while this phase needs

<table>
<thead>
<tr>
<th>Defect Cause</th>
<th>Defect No.</th>
<th>Total SDLC Errors (%)</th>
<th>Err/Male (%)</th>
<th>Er/Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Err</td>
<td>Dev. Err</td>
<td>Test Err</td>
</tr>
<tr>
<td>Omission</td>
<td>D1</td>
<td>58.40</td>
<td>25.57</td>
<td>32.83</td>
</tr>
<tr>
<td>Lack of Knowledge</td>
<td>D2</td>
<td>81.92</td>
<td>22.73</td>
<td>59.19</td>
</tr>
<tr>
<td>Mis-Communication</td>
<td>D3</td>
<td>68.65</td>
<td>22.45</td>
<td>46.20</td>
</tr>
<tr>
<td>Accidental</td>
<td>D4</td>
<td>72.82</td>
<td>19.55</td>
<td>53.27</td>
</tr>
<tr>
<td>Transcription</td>
<td>D5</td>
<td>25.02</td>
<td>10.33</td>
<td>14.68</td>
</tr>
<tr>
<td>Process gap</td>
<td>D6</td>
<td>28.07</td>
<td>12.44</td>
<td>15.62</td>
</tr>
<tr>
<td>Shortage of Time</td>
<td>D7</td>
<td>31.27</td>
<td>8.71</td>
<td>22.56</td>
</tr>
</tbody>
</table>

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the careful and perfection in developing software; that is why errors are maximum (25.57% in total, 17.56% by males & 8.01% by females) due to omission that is due to careless behavior of employee. Second highest errors are due to lack of perfection in nature or due to miscommunication. This shows that reserve nature also plays an important role for committing errors.

5.2 Testing Phase:
All testers must have a characteristic to be perfect in their work so as to pinpoint the mistakes done by development team. Anybody lacking this will commit maximum errors (59.19% in totality, 40.44% by males, 18.75% by females). Transcription and process gap errors are minimum in testing phase. Shortage of time also effects the testing errors (22.56%) in big way in comparison to development time (8.71%). On gender basis it was analyzed that females commit less errors in comparison to male for any defect root cause.

6 Conclusion
In this paper attempt has been made to analyze the errors that have occurred at various stages of SDLC. Root cause for their occurrence is also classified as omission, lack of knowledge, accidental, miscommunication, transcription, process gap or shortage of time. These root causes are further analyzed cognitively with respect to certain human behavior parameter taken in this study. These parameters are like carelessness/ ignorance, perfectionism, reserve personality, attitude of personality, dominance & less vigilance personality and emotional stability factor. It was found that perfectionism, reserve personality and ignorance or careless nature is the root cause for error occurrence.

On, gender basis it was analyzed that females commit less errors in comparison to male for any defect root cause. By removing the root cause for the error occurrence, one can create the healthy working environment at IT companies. It will also help the IT managers to select the SDLC team with proper, positive and compatible attitude employees. Such steps will strengthen the employee job satisfaction and job involvement, thereby increasing the employee retention. This will also indirectly help in completing the projects in time, reducing the software cost and optimizing the resources. All such kind of measurements will help in improving the quality of life also.

7 Further Scope
This UGC Sponsored project is an ongoing project. In future data will be further analyze and quantify the statistical relationship between different parameters of cognitive human behavior and root cause factors.

Figure 2 The graphically representation of table1

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8 References