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THE EXTREME ENGINEERING FOR GLOBALIZATION OF NATIONAL SOFTWARE INDUSTRY (TOTAL QUALITY MANAGEMENT FRAMEWORK)

M. I. Khan & M. A. Qureshi
COMSATS Institute of Information Technology,
Islamabad, Pakistan.

Abstract
The small and medium software development firms are becoming the forward troupe in the field of Information and Communication Technology by providing software development services to small, medium and large enterprises. In this way, software industry of a country contributes to its economy by generating revenue from its quality product/services. It also facilitates industrial sectors like cement, textile etc. in transformation from conventional to knowledge economy. The present research focused the performance of SMEs at national software industry from quality perspective. The authors used triangular methodology i.e. Questionnaire survey (250), interviews (30) and case study (Digital Spinners and Icon Systems) for data collection. The paper evaluated the quality assurance standard (CMM, ISO) deployed in 1,419 firms registered at Pakistan Software Export Board since 1996 to 2008. The authors investigated the adoption trends of software development methodologies by small and medium software development enterprises. The content analysis and proportion methods applied for statistical investigation. The results revealed that extreme engineering (shared TQM practices and software engineering methodologies) significantly contributes to the success of projects, products and services for large profit share from globalized world. The deployment of extreme engineering practices will prepare software industry to participate, compete and enjoy the benefits of knowledge economy which leads nation towards peace, pleasure and prosperity.
Key Words: *Extreme engineering, Globalization, ISO, Software engineering, TQM*

Introduction

The extent of national IT industry is about US$700 million, with annual software industry turnover of about US$70-80 million (Pakistan Software Export Board, PSEB, 2006). During the fiscal year 2003-04, more than US$200M invested by the financial services sector into IT infrastructure deployment. Moreover, the total spending value of some ongoing large IT projects of the public and private organizations exceeds US$100 million (Pakistan Software House Association, P@SHA, 2006)

Pakistan's IT industry is still performing very below as compared to its potential. Generally, Pakistan's economy is 1/5th of the Indian economy. The size of the Indian industry is US approximately $26 billion comprises at domestic contribution at US$8.2 billion and international at US$17.9 billion; which implies that Pakistan's IT industry has not kept up pace with the other sectors of the economy and its size should be at minimum level of US $ 4 to 5 billion. It is

also noted that the ratio of Pakistan's export revenue to the domestic revenue is only 17%, whereas the same ratio of the Indian software industry is 218% which signifies that there is enormous space for growth of the software export revenue in Pakistan. According to Pakistan Software Export Board (PSEB), National Software Industry has poor infrastructure, provide moderate quality and serve at low cost to market as compare to India, Russia, and Singapore.

The trends of software firms start-up is increasing with the passage of time at national and International scale. Pakistan software industry is unable to build its concrete values to attract national and international clients. This shows that there is a need to improve the quality of services, products and projects running in the industry along with strong IT-infrastructure. There are 495 firms in Karachi, 459 in Lahore, 373 in Islamabad and 92 in other cities of Pakistan. (*PSEB, 2008)*

The projects or products development work is very low as compared to other countries. The situation is alarming in software industry from quality perspective that blocked its performance at local as well as global scale. Presently, International Standard Organization (ISO) quality certified software firm proportion is low and the Capability Maturity Model Integration (CMMI), another quality assurance standard is very low. There are 8% ISO certified and 1% CMM and 91% firms operating without any standard. The Government of Pakistan has established Software Technology Parks (STPs) in Islamabad, Karachi, Lahore and Peshawar to promote national software industry but there is more need to emphasize on the quality of the software projects, products and services for the satisfaction of local and global clients.

Thus, software firms should measure their performance by satisfying the questions i.e. Is top management involved in product or service development? Is quality of product or service meeting the standard? How many important opportunities did we miss? What are the expectations of our customers? Are we empowering our employees? Is software reasonably bugged free? Is it delivered on time? Is it completed within budget? Does it meet requirements and expectations of customer? Do our firms implement any quality standard? There is a need to answer these questions for the betterment of software and other industrial sectors textile, cement and agriculture etc.

Research Objectives:

The objectives of the present research paper are following:

1) An investigation of current software engineering methodologies deployed in small and medium enterprise in national software industry.
2) Promotion of national software industry to positively place it on software offshore outsourcing map as trustful offshore outsource destination.

Research Limitation

The performance of software industry can be evaluated from different parameters i.e. requirement engineering, programming languages expertise, database management systems skills, ERP consultancies, networking services and IT business consultancy. The present research is limited to software engineering practices are being used in national software industry.

Research Justification

In future, knowledge economy will change the nature of associations to economical, political, social or entrepreneurial. E-readiness means preparation of nation, firm to participate electronically. So a firm should be e-ready to participate in knowledge economy (Economist, e-readiness ranking report, 2007). Thus, e-readiness of firms from every sphere of life has become the core requirement of any sector due to globalization. There is an essential need for evaluating the software development practices at national software industry for the betterment of software business at local and global scale.

Research Significance

The conventional world activities are transforming into the globalized world. It means all organizations must have to transform their traditional functions into digitalization process. In this way, they enable themselves to participate in the globalized world. Thus, the enablers (software firms) of business are required to be prepared electronically (e-ready) to serve quality products/services to its global customer. Thus, level of significance of current research is high.

Literature Review

In knowledge economy, software firms have become catalyst to economic growth and development for any country. Software appears as a strong enabler of economic growth (al-Jaghoub 2004, Heeks and Nicholson 2004, Kambhampati 2002). In globalization, software is intrinsic part of different industries like telecom, transport, medical, education and other industrial sectors. It plays operational as well as strategic role enabling firm towards flexibility, time saving and reducing costs along with maintaining quality in its processes, products and services (Dromey & Rout 1992; Geck et al, 1998). Therefore, software is known as a core element of cars, watches, television and many other commodities that are used regularly in daily life (McKerlie Consulting 1996). But the methodologies used to develop this tool are not aligned with the firm culture, capabilities and practices. Therefore, majority of software projects failed in different industries. A survey of 232 firms was conducted in multiple industries including government, information technology, communications, finance, utilities, and healthcare software systems (Robbins-Gioia 2001). The findings are the following:

a) 36 % were in implementation process.
b) 51 % viewed as unsuccessful
c) 46 % does not understand how to use.
d) 56 % know program management office in place, and of these respondents, only 36 % ERP implementation was unsuccessful.

Similarly, The KPMG Canada (1997) revealed the research findings that more than 61% projects failed. 30% exceeds more than three quarters from schedules, more than half exceeded their budgets by huge scope. In this study, it is claimed that "*an estimated $25 billion is spent on software application development in Canada per year but unbudgeted expenditures also run into the billions of dollars. It is only because the practices adapted for the software development are not up to the mark*".

The findings exposed that one of the reasons behind is software engineering discipline. In fact, software engineering research has been criticized from two perspectives. First, researchers are not aware of what developers are doing in reality (Fitzgerald 1997, p202. Secondly, many of these practices, methods, techniques and standards are not thoroughly assessed. (Fenton, Pfleeger & Glasss1994; McBride 2004) and may not be recommendable for all software development firms (Bucci, Companai & Cignoni 2001, Kautz 1998b, Pfleeger et al. 1997, Richardson & Ryan 2001, Wilkie, McFall & McCaffery 2004). Therefore, it is essential to identify the best software development practices for the success of software products, projects and services. In this competitive market place, it is necessary to improve the performance of software industry by delivering qualified product and services to attract local and global customers.

Research Methods & Framework

The present research is based on the primary and secondary data. The authors used triangular research methodology that comprised of questionnaire, interviews and case studies. Five likert scales used. Those small and medium software development firms included in the survey that were registered in Pakistan Software Export Board, Islamabad. The total IT related companies registered at Pakistan Software Export Board were 1419. The authors conducted pilot case studies of two firms to develop survey instrument. After the consultative approach, the instrument was sent to 250 software firms and 181 responses were received back. The questionnaire survey was conducted in software development firms of Islamabad, Peshawar, Lahore and Karachi to be filled by project manager, software engineers, programmers, IT professionals and received a response rate calculated was 72%. The telephonic conversation and email service is used as communication tool i.e. questionnaire follow-up. The detailed interviews and case study (*Digital Spinners and Icon Systems*) were conducted for more accuracy in results. It provided us opportunity to measure the software development process via contents analysis technique and observation

method. To avoid the inconsistency associated with data gathering across multiple sources, the data was crosschecked. The data was collected in third and fourth quarter of year 2008. The responses were recorded in Microsoft scheming tool and results were shown in the forms of tables, charts and graphs.

Results Analysis

The deployment of right software engineering technique in software development process is the basic step to maintain quality in software products/ services because it helps in identifying the specification, "What to Build". The software firms manage quality by implementing the approach with outcome in fewer defects, times and value to the clients. Thus, the best approach for software development is the one that is successfully delivered and deploys a software system by satisfying its customer's specifications at 360^{o}.

The results found in response of research (survey, interviews and case study) are described in the following manners. First, software engineering methodologies being used in software firms are identified along with their comparative analysis. Second, the responses obtained from different questions presented in the forms of tables, charts and graphs. The investigation identified the following generally followed software engineering methodologies during development process at national software industry. The authors validated the data by onsite observation and viewing the original documentation of software projects.

Waterfall Methodology

In software development, the most simple development methodology is "waterfall". The reasons for success are its guidance to breakdown work in stages, content reviews among stages for continuation of process. The chief technologist of Digital Spinners comments that "*It is oldest and heavy weight methodology which is generally used in our software firms while it becomes obsolete for international developers.* In response of question what do you mean by heavy weight? He argued that "*it slowdown the process and unable to adopt fast marketing changing requirement*."

Prototyping Methodology

It is the framework of activities during software development i.e., incomplete versions of the software program being developed. Prototyping can also be used by end users to describe and prove requirements that developers have not considered. The expert[1] argued that "*The client and the contractor can compare if the software made matches the software specification, according to which the software program is built. It also allows the software engineer some insight into the accuracy of initial project estimates and whether the deadlines and milestones proposed can be successfully met*".

[1] interviewee from software firm

Spiral Methodology

The "Spiral Model" is another one used in software development. The general comments are recorded from a team of software engineers as "*its incremental and iterative nature helps in success of software projects/products, where the team is able to start small and benefit from enlightened trial and error along the way"* and "*The spiral methodology reflects relationship of tasks with rapid prototyping, and concurrency in design to builds activities"* Moreover," *It helps in identifying deliverable/outcomes are identified in each software development life cycle step*".

Rational Unified Process

The Rational Unified Process is an extensible framework which should be customized for particular firms. Agile Unified Process is a simplified version of the IBM Rational Unified Process. The expert from Icon Systems viewed as "*It describes a simple, easy to understand approach to developing business application software using agile techniques.*"

Capability Maturity Model (CMM)

It is developed by Software Engineering Institute and is for mature organization. It has different level of maturity. The director technical at software Technology Park argued that "*All software firms having any level among 2-5 are regarded by intelligent clients and certified firms can have better image in international market*."

Agile Development Methodology

It is the latest one used for agile software development process. The Project Manager of a firm explained it as "*It has many methods, promote development iterations, teamwork, collaboration, and process daptability throughout the life-cycle."* Another expert (interviewee from software firm) argued that "*It helps in minimizing the overall risk, allows the project to fast adaptation of changes and documentation is produced as required by stakeholders.*" The general response about this methodology recorded as "*It have specific tools and techniques such as continuous integration, pair programming, test driven development, design patterns, domain-driven design improve quality and enhance project agility*."

Comparative Analysis & Findings

The research process revealed the following comparative points of each methodology.

a) Waterfall
   1) divide work in stages
   2) reviews contents between stages
   3) slow and awkward in nature
   4) heavy weight model
   5) changes are difficult and costly

b) Prototype
   1) incomplete initial sample of software
   2) attempt to reduce failure risk
   3) breaking a project into segments
   4) changes adaptive
   5) user involved throughout the process
   6) helps to know “what to build”

c) Spiral Model
   1) incremental and iterative
   2) trial and error functioning style.
   3) reflects the tasks association
   4) identified outcome at each step

d) Rational Unified Process
   1) Iterative and incremental in nature
   2) use cases for “what to build”
   3) insists on architecture
   4) multiple models are available
   5) focus on the most critical risks
   6) variations or refinements control

e) Capability Maturity Model
   1) Process improvement approach
   2) integrate separate organization function
   3) providing guidance for quality processes
   4) delivery of all kinds of services
   5) continuous and staged

f) Agile Methodology
   1) agile and iterative
   2) lighter, faster, more people-centric way
   3) Customer satisfaction
   4) Simple and adaptive
   5) Self-organizing teams

The comparative analysis revealed that CMM and Agile methodology are the best for quality products and continuous software development process improvement. However, these methodologies deployment required highly skilled programmers, task specialists at high price. A stream of continuous studies indicate that the best designers produce structures that are faster, smaller, simpler, cleaner, and are produced with less effort (H. Sackman, W.J. Erikson,

and E.E. Grant, 1998). Thus, it is difficult for small and medium enterprise to implement CMM and Agile methodology due to high skill cost.

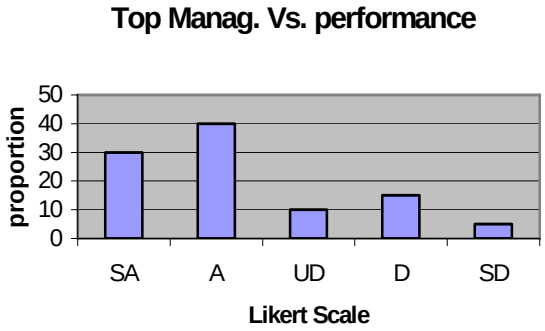
Findings

Following statistical responses were found. The findings presented in the form of tables and graphs after applying the proportion or percentage method:

Q. Does involvement of top management effect on efficieny?

Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree
30%	40%	15%	10%	5%

The responses exposed that involvement of top management in projects and process improves the effectiveness of a firm. According to John S. Oakland, "effective leadership starts with the chief executive and his top team". The low quality software can be avoided by top management involvement as TQM requires "the executive to provide an inspirational vision, make planned directions that are understood by all and to inculcate values that guide subordinates, team members" (Nayantara Padhi, PhD, a six sigma expert). Hoffherr *et al*. (1994) stressed on the significance of top management being focused minded to have higher drive for firm excellence.

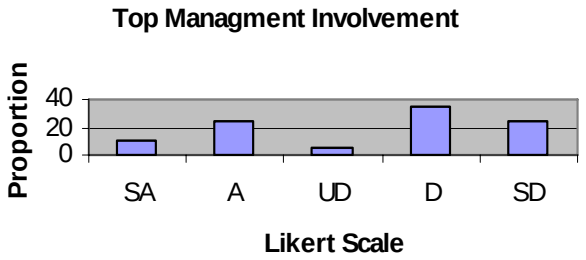


Q. Do top management involve in the software development process?

Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree
10%	25%	5%	35%	25%

The responses revealed that involvement of top management in projects is not in practices at national software industry which may lead the project toward failure. Robert N. Charette (2005), said in his article why software fails? *"A lack of upper-management support can also damn an IT undertaking. This runs the*

gamut from failing to allocate enough money and manpower to not clearly establishing the IT project's relationship to the organization's business".

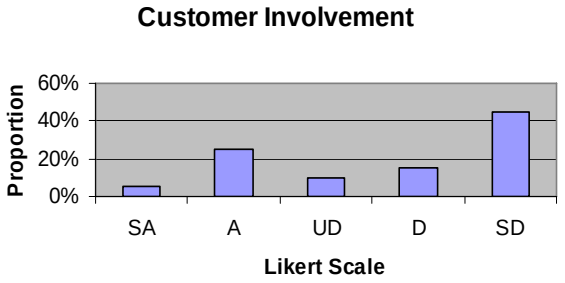


Q. Do you involve customers till project closure?

Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree
5%	25%	10%	15%	45%

The responses showed that software firms does not involve customer till the completion of the project which leads to incomplete specification. The involvement of end user is core requirement for the success of a software project. Detlev D. Hoch (1999) stated in his book entitled "secrets of software success" published Harvard Business Press in which 100 companies around the world discussed that how world leading software firms are reserving more and more resources for the involvement of end users?.

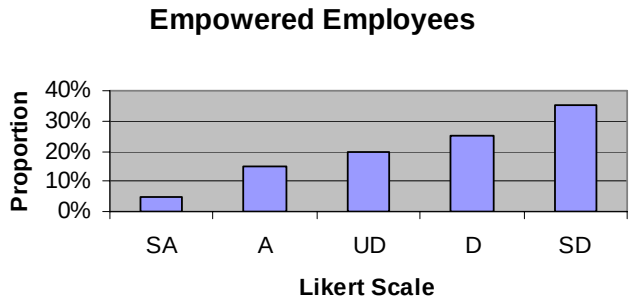
He narrated that "*Microsoft has its own usability lab i.e. separate rooms equipped with one-way mirrors, cameras and other equipment. All of them observe and record tests by end users. Customers are usually very supportive and ready to contribute. Some of them even become overnight guests at software firms. When Net dynamics, Sun's Silicon Valley based network application tools subsidiary, developed its version 2.0, one customer basically lived an entire week at the development site to interact more closely with developers"*



Q. Do you empower employees during software development?

Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree
5%	15%	20%	25%	35%

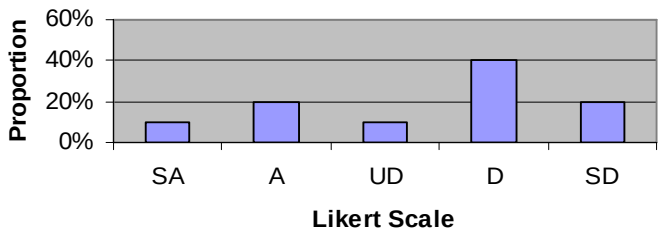
The results revealed that only 5% respondents strongly agreed to empower their employees and 15% just agree. It means failure of quality remain constant until employees are empowered. It is stated (John, 2002) that "*ordinary people can be made to do extra ordinary things by involving them in the software development practices*". According to Milakovich (1991) TQM is an encompassing management approach whose principal tenets are to satisfy the internal and external customers need strategies of employee's empowerment and performance measurement.



Q. Do you benchmark best software practices?

Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree
10%	20%	10%	40%	20%

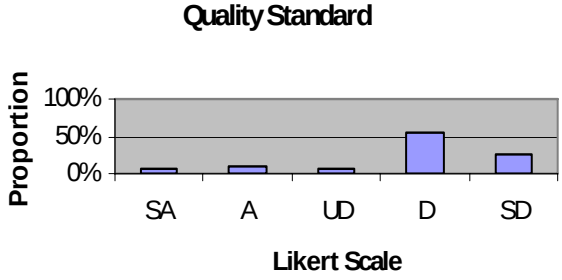
The responses revealed that software firms are not ready to bench mark the best practices. They believed on firm's internal strength and capability which leads them toward the deficiency of skills, explicit knowledge and demand of customers. The bench marking is core of TQM which used to improve process by comparing with world class or best class firms in its practices (Dean & Bowen 1994). Moreover, Chiles & Choi stated that "*All firms benchmark to gain knowledge regarding industry best practice and learn how they can improve the efficiency of their own work processes and ultimately better satisfy their customers with improved products and services (Chiles & Choi 2000).*



Q. Have you deployed quality standard for software development practices?

Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree
5%	10%	5%	55%	25%

The response shows that no quality standards are deployed at software firms which lead towards the low image of firms in local and global market. The experts revealed that "*standards for developing software in a consistent and logical manner. The primary benefit of adhering to software standards is efficiency. Standards enable each member of a software team to work anywhere in the source code without needing to recognize and adopt a different programming style*". One of experts (interviewee) comments were documented as "*any programmer can look anywhere in the sources with reliable expectations about how the code will be structured, what objects are, and how to find what they need. In addition he stated that maintenance, revision and shared use of code are simplified*". It is critical to realize and recognize that following standard (ISO, CMM, ANSI, IEEE) is more important than the details of programmer's own work, documentation etc.



Discussion

The challenges of the software failure have strong relationship with the complexity of the software process and the immaturity of software engineering as a profession. The major factors idenfitifed during the research revealed that software project running "over-budget", running "over-time", "inefficient due to low quality", "no conformance", confused code", "never delivered or software not used by end users". According to Frederick P. Brooks (1987), there is no "silver bullet" which means no single methodology will prevent software overruns i.e. budget, time, quality and other failures. The experts viewed and expect advances in artificial intelligence to solve the problems and provide software productivity and quality (IEEE). In the knowledge economy, "*individuals, firms, and countries will be able to create wealth in proportion to their capacity to learn and share innovation*" (Foray and Lundvall, 1996; Lundvall and Johnson, 1994). Moreover, Agresi, Jeffery and Klin et al. argued that "*the academicians, professionals and researchers are advised to user*

forceful theories and models from social sciences, economics, management and firms to study software engineering in the context of organization and institutional practices" (Jeffery 1993; Klin etal. 1992).

Researchers have used diversified theories and concepts from multiple disciplines to explain the concepts related to software process development for the betterment of software industry. In this context, "Shewhart concept of quality extended by Joseph Juran, W. Edward Deming and Kaoru Ishikawa to form the total quality management approach." Powell (1995) found from the output of 54 firms study that "*TQM could produce economic value to the firm*". In comparative analysis of TQM and ISO 9000, Zhang (2000) research showed that TQM has much better effects on overall performance of than ISO 9000 along with reducing quality costs to SMEs. Similarly, Anderson and Sohal (1998) found from the analysis of survey responses from 62 SMEs that significant positive relationships between TQM practices and organizational performance. Therefore, it is clear from the discussion that TQM can provide benefits to software firms in successful software development. Therefore, the interests and efforts of firms toward deploying TQM philosophy are worldwide adequate and growing rapidly (French & Bell 1995). The authors argued that joint venture of software engineering and TQM practices can lead towards successful project, products, and services to improve the performance of the industry at local and global scale.

The authors called these blend, "*extreme engineering*". Savolainen (2000) argued that "*TQM is a management approach which aimed at incorporating awareness of quality in all organizational processes*" instead of specific project, product or process. According to Ugboro and Obeng (2000), "*It is based on; continuous improvement, top management leadership and commitment to the goal of customer satisfaction, employee empowerment and customer focus*". Thus, it is called extreme engineering as it will work on extreme ends of an organization i.e. starts from top management and ends on customer satisfaction. According to Quazi and Padibjo (1997) TQM means a turnaround in corporate culture. Extreme Engineering will affect the organization at 360^{o} instead of specific unit or process to create innovative culture for continuous improvement in performance of software industry in the form of quality process, product and project deployed and delivered by software firms.

Conclusion

The software engineering practices identified are unable to provide a solution to the problems. The research concludes that software firms are not performing with its full potential either it is project oriented or product oriented because the software methodology adopted are not sufficient and are not effective in nature. The CEOs and project managers are not taking care of quality standards. The software firms are failing to satisfy their clients.

Therefore, there is a need for the blend of software engineering practices with TQM practices. The extreme engineering deployment will uplift the morale of employees by empowering them as well as customers by involving them in software development process with the support of Top Management. The extreme engineering will satisfy the customer with low cost, short time and required quality in software projects, products and services. It will direct the software firms towards the quality standards and international certification to globalize the national software industry.

The quality certified firms will attract more customers from local and international market to generate more revenue for the betterment of employees, owners and nation. This leads toward economic prosperity that will bring social prosperity in the country. The software firms will become star of the nation as it assists automation process and productivity enhancement. In this way, firms as well as business people, academicians, researchers; consultants will enjoy peace, pleasure and prosperity in the globalized world and will be truly benefited from knowledge economy.

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