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Software Process Improvement Standards Implementation: An Empirical Survey in Educational Institutions of Upper Sindh

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Abstract: Software quality has emerged as a crucial need of today's industries, businesses and academia. Software Process Improvement (SPI) has grown popular approach for betterment of software products. The issue of software quality has been taken into account .The quality of developed software applications is not at its best because the developers .The low quality leads to many a great problem on micro as well as macro level. In this paper, the survey data is presented characterizing the implementation of SPI in eight institutions of upper Sindh. A questionnaire was designed according to classical questionnaire design principles for getting the qualitative data. These questionnaires were filled by software developers, project managers, database administrators and software practitioners. It was found that the software products being used . Specially, for the projection of such software applications, there are some key processes which are mandatory for the reliability and validity of software products but these precautions have usually been overlooked during their development. The core reason behind such low standard development of software products is due to the limited awareness about international standards of software development processes, financial constraints.

Keywords: Software Process Improvement, Software Standards, Questionnaire, Survey Design

1. INTRODUCTION

Quality is a standard of a thing which is measured and analyzed by how much valid and reliable it is, while, the process is a systematic path to the development or improvement (Sommerville, 2001). Recently, software quality has become much important and inevitable in different industries including academia. This is because of emerging role of software in modern-day business and education. The significance of software and its role in the institutions have revealed that the better quality will lead to the better performance of the institutions. The dependency on software has also created the question of how much reliable, valid and productive the software products are which are run in the respective institutions (Hoyer, *et al.,* 2001).

SPI has risen to a considerable degree of popularity for the delivery of improvements in software products (Humphrey, 1989). Many organizations have been practicing SPI following different appraisal models focusing on different maturity levels aiming to change the practice of their software work. Getting success in SPI has shown to be a difficult challenge for many institutions. Introducing process changes to achieve organizational objectives which are usually focused on quality improvement, cost reduction and schedule acceleration Because of the increasing use software in all aspects of our life, the software firms need to manage and develop their software processes to meet the customers needed (Layman, 2005). According to (Bae, 2007), most software firms facing tough competitions struggle to develop the quality of its software within specific time and suitable budget to achieve business needs to satisfy its customers. (Allen, 2003) also believed that the increasing use of software systems that lead to the complexity of these systems and the need to understand and manage the software development process to ensure high quality, suitable cost and maximize productivity. According to (Wang, *et al.,*2000) the SPI is a systemic procedure for improving the performance of an existing process system by changing or updating the process.

The software being used in the higher educational institutions of upper Sindh, are not up to the mark in terms of international standards of software development processes. Specially, for the projection of such software applications, there are some key processes which are mandatory for the reliability and validity of software products but these precautions have usually been overlooked during their development. The core reason behind such low standard development of software is due to the limited awareness about international standards of software development processes and its exposure at every level from bottom to top. Institutions generally appoint software developers or programmers, considering them one-for-all tasks of software developments and processing, whereas, at the each stage of software development process, a separate expert is required to maintain the standard of relevant component, for instance, analyzer, designer, programmer, tester and software quality manager. Hence, only a software developer is not enough resource for this all. The outcome of our research is

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what, how, and how much of SPI standards are followed in the educational institutions of upper Sindh by software developers.

2. MATERIAL AND METHODS

Questionnaire and Survey Design

The observation of problem led to the questions and the questions yielded a motivation for this research. In order to find the answers to these questions, we prepared a comprehensive questionnaire containing 20 questions. The questionnaire was designed according to classical questionnaire design principles (Humphrey, 1989). The questions covered a range of possible affecting factors which were expected to be found in the answers. The questions included some open and other close-ended ones. The questionnaire was also designed to elicit the perceived level of effect of each barrier to SPI implementation. Hence the respondents were supposed to mention the level of effect (i.e. High value, Medium value, Low value, Zero value, or Not sure) of each barrier SPI implementation. Moreover, the survey design process is adopted similar to (Jennifer, *et al.,* 2010).

These questionnaires were sent to 96 persons working in different educational institutions of upper Sindh. Among 96, we received response of 51 persons and other remained silent or with no response. The responding ratio stood 53.12%. Among 51 who submitted their response, 13 were software developers, 6 were project managers, 11 were database administrators and 21 were software practitioners. The aim was to collect quantitative and qualitative data characterizing the implementation of process improvement in the software development process.

Data Collection

After the testing of the developed questionnaire, we set off to find the higher education institutions that run the software products for different types of management. We found 8 institutions meeting our criteria of research: Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Shah Abdul Latif University, Khiarpur, Sukkur Institute of Business Administration, Sukkur, Ghulam Mohammad Mahar Medical College, Sukkur, Chandica Medical College Larkana, Mehran Engineering University Campus Khairpur, COMSIT College of Management Sciences and Information Technology, Sukkur, Sukkur Institute of Science and Technology (Sistech), Sukkur.

The persons working in the related fields were sought out in the said institutions. The total number of respondents stood 51 whom we classified according to their professional positions. The division of respondents has been represented in **(Table 1).** Each was in one or other way concerned with the development and management of the software products. The questionnaire was then distributed among them in confidence and they were given enough time on their own disposal so that we could get maximum of their response to the questions in real sense. After the given time, we collected the questionnaire filled in by the respondents.

Table-1 Respondents Division

1	Software Developers	13
2	Project Managers	6
3	Database Administrators	11
4	Software Practitioners	21
	Total	51

3. SURVEY RESULTS

Survey results conclude the validity, reliability and authentication of the research work. This section presents the results that we have received from the respondents. Before going through the received results, we shall take a look of what we asked and what we received in the response. It is necessary to state the question and the nature of question. Therefore, in the next sections we shall see the questions, their nature and classification and the response that was given by the respondents. Out of 20 questions, we have entertained 16 questions here for they are the one related to the core of the research. Moreover, we have divided these 16 questions into 4 different categories. This we did so that results can be more easily defined and directed to the goal of the research and its outcomes.

Employees Experience in Software Development

Software development is a technical field which does also require a practitioner or developer to have an enough experience so that the product will be accordingly benefiting the organization if it is developed and run by an experience person. For this cause we asked "What is the average software development experience of employees (team) in your institution?" The response to this we received that 10% persons were found having software development experience of less than 1 year, 73.6% had 2-5 years and 16.4% more than 5 years. The graphical representation of these figures is given in **(Fig.1).**

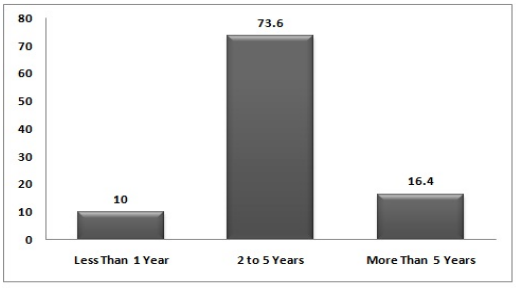


Fig.1 Employees Experience

SPIs and Critical Success Factors (CSFs)

The knowledge of CSFs is a must for the software developers. The question was "Does software developers have enough knowledge about the SPI and CSFs?" The response to this question was encouraging as the answer to this question was replied with YES by 83.7% persons and 16.3% had their replies in No. **(Fig.2)** gives the graphical representation of these figures. After that, the question was "How much Software Developers have knowledge about software process improvements implementation?" Though, the results of this question do not carry a decisive point, the percentages of the codes have little differences among them. The people with high knowledge were 3.33%, with good level of knowledge, we found 43.33% people, 26.67% people had average level of knowledge, and people having low knowledge were at 20%. We also had no responses from 6.67% people. The graphical representation of these results depicted in **(Fig.3).**

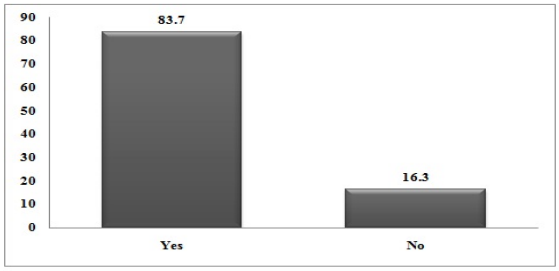


Fig.2 Employees' Knowledge of CSF

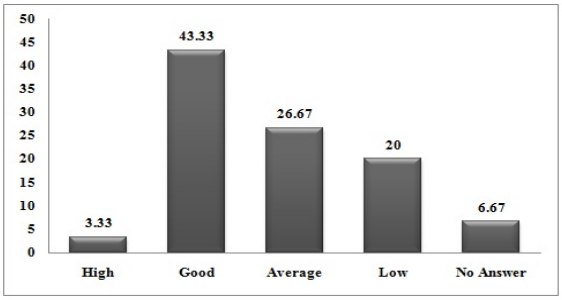


Fig.3 Employees' Knowledge of SPI Implementation

We need to know the utilization of software developer's knowledge so we questioned "At what level, software developers utilize their knowledge of SPIs and CSF factors?" The results show that most of the people have average level of utilization of their knowledge as we find 66.67% people at this level, 10% people are at the low level and 10% people have high level of the utilization of their knowledge. We also find 13.33% people who had no response to this question. We have graphically depicted the results in **(Fig.4).**

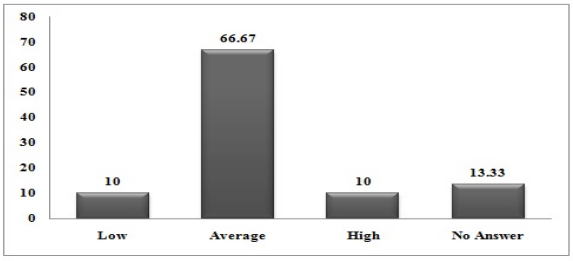


Fig.4 Employees Knowledge Utilization Level

After knowing their concerns for CSFs, the question we put was a try to know that which CSF is the most influencing and effective one. The question asked" In the case your answer is "Yes", which CSFs are important for SPIs?" The response options were given as examples separately so that the most and least important considered factor should be taken out. The result came that the importance ratio of Senior Management Commitment (SMC) was found12.9% for success of SPIs, Staff Involvement (SI) was found at 6.45%, Experiences Staff (ES) stood at 5.48%, Software Process Improvement Awareness and Implementation (SPIAI) was given an importance ratio of 16.13%, Staff Training (ST) was considered 22.58% important, Allocation of Resources (AR) counted for 3.23%, Communication and Collaboration (CC) had nothing with success percentage so it came with 0%, and Organization Politics (OP) played a critical role at 3.23%. The graphical representation is given in **(Fig.5).**

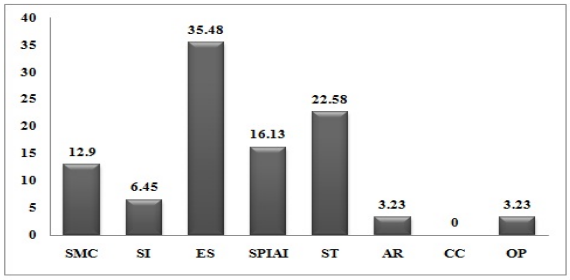


Fig.5 Critical Success Factors Role in SPIs

Strategy to Improve Software Development Processes

The second classification of the questions is the intent of the institution for the improvement of software development process. We inquired to the employees, "Has your institution tried to improve its software development process?" This question regarded the efforts of the institutions to improve their Software Development Processes. It carries positive response more than the negative as the Yes stands at 83.33% and only 16.67% had to say No. The graphical representation of the results is given in **(Fig.6).**

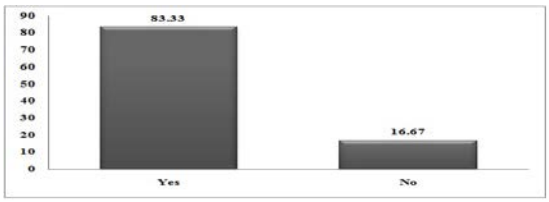


Fig. 6 Institution Trial for SPIs

In a positive response of measurement question, it is considerable to know the stages that are followed by the institutions for the improvement of software. We asked the question "Process measurement, analysis and change are three stages in process improvement. How many stages you have followed in your institution?" As applications with reference to the stages of these measurements were asked in this question so the result showed 40% people following only first stage, up to second stage 30% people followed, all the three stages were followed by 20% people. 10% came back with no response. We have given the graphical representation of these results in **(Fig. 7).**

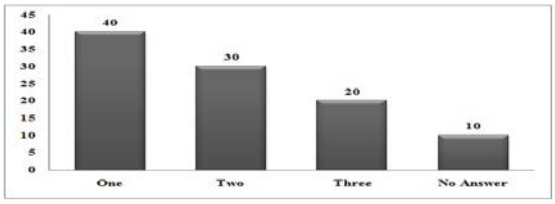


Fig.7 Application of Process Improvement Stages

After the stages questions, we asked about the model used in the institutions for the software process improvement. The question was "Software testing process provides set of levels and an assessment model, and presents set of recommended practices that allow institution to improve their software process, for this, which model you have used?" The result showed no majority or monopoly of any improvement model. Testing Improving Model was used by 30% people; Testing Maturity Model was used by 26.67% people and Total Quality Model by 33.33% people. 10% returned with no response to this question. Usually, these three improvement models are used for Software Development Process. The graphical representation of the results of this of this question is depicted in **(Fig.8).**

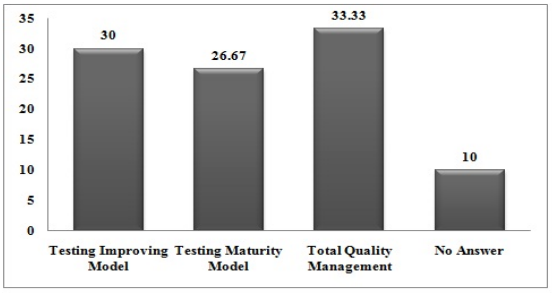


Fig. 8 The Use of Improvement Models

After knowing the model, we needed to inquire the complexities occurring in SPIs and the level at which they accordingly appear. We asked "At which stage you have identified the process improvement bottlenecks and weaknesses?" This question was to analyze the troubles and problems while improving the Software Development Processes. 16.67% replied that they had to face such situation at Process measurement, Process Analysis was felt the hard point for by 56.67%, and 20% had it at Process change. 6.67% was received with no answer **(Fig. 9).**

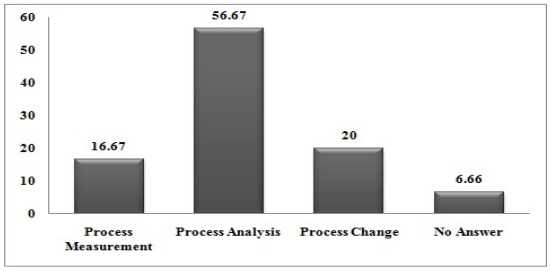


Fig.9 Complexities in SPI at Different Levels

Software Process Improvement Experienced in Institutions

This classification of questions is based on the experience of the institutions with the SPI programs. In case of the existing program for SPI, the employees' motivation to the program stands as a matter of concern. Therefore we asked the employees, "At what level, you are satisfied from existing implementation in your institution?" In response to this question we found that 22.58% people were found highly satisfied, the average satisfaction was found with 67.74% people and dissatisfaction was found on the part of 9.68% people. We have given in **(Fig.10)** the graphical representation of these results.

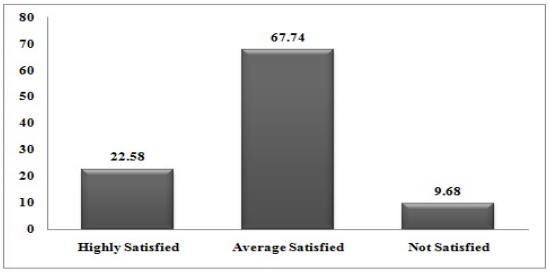


Fig.10 Satisfaction Level of Employees with SPIs

The next question was whether the institutions adopt any process improvement models or not and if they improve their software products with certain models. The question was "Does your institution adopt process improvement models?" This question was replied with the Yes ratio of 54.83% and No ranked at 45.16%. **(Fig.11)** shows the graphical form of the results.

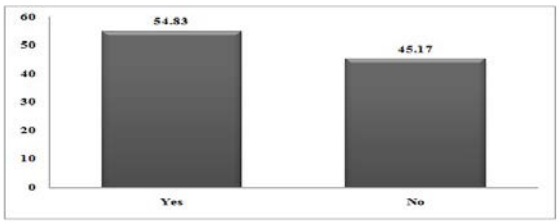


Fig.11 Adoption of Improvement Models in Institutions

We wanted to know that which model is most frequently and successfully used and yielded good performance. The question was "In case your answer is "Yes", which process model is used?" The result showed that ISO 9001/ 9000-3 was used by 17.65% people, CMM Level 2 was preferred by 23.53% people, 11.76% people used CMM Level 3 or Higher, CMMI was used by 5.88%, SPICE was adopted by 11.76% people and 29.41% people used other PIMs. The graphical representation of the results is given in **(Fig.12).**

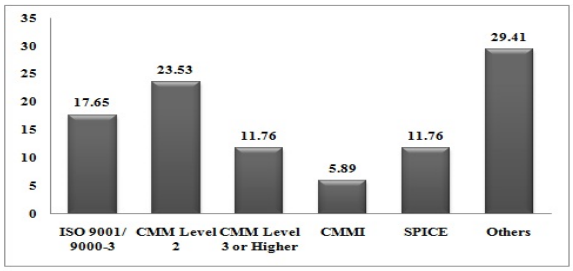


Fig.12 Usage of Different Improvement Models

After that, the question was "Is there any software process improvement education program in your institution?" Apart from the individuals, we also accounted for the institutions whether they had their SPI education program for their employees or not. We found more institutions having no such programs for their employees as the ratio stood 63.33% of those institutions that don't have this facility, whereas 36.67% institutions have SPI education programs. **(Fig.13)** represents the graphical form of the results.

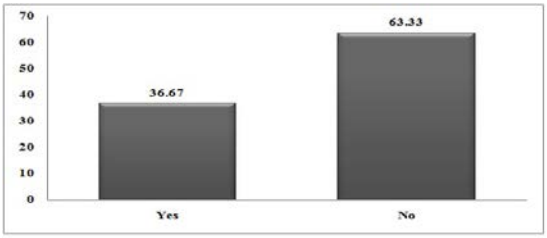


Fig.13 Availability of SPI Programs at Institutions

The improvement of software requires three consecutive activities. The question was "Software Process Improvement has to undergo three continuous activities, in your institution which activity is continuously experienced in your institution?" Planning as an SPI activity was used by 22.58% people, 51.61% people performed monitoring activity and control was performed by 25.81% people. The results are given in graphs in **(Fig.14).** We also examined the foreseeing capability of the institutions. The higher education institutions need to plan for long rather than for short periods of time. We asked "Does your institution focus on long term or short term benefits?" We found Long term benefits focused by 70.97% and Short term benefits by 29.03%. The result shows encouraging figures for our higher education institutions. We have given graphical representation of the results in **(Fig.15).**



Fig.14 Use of Software Process Improvement Activities

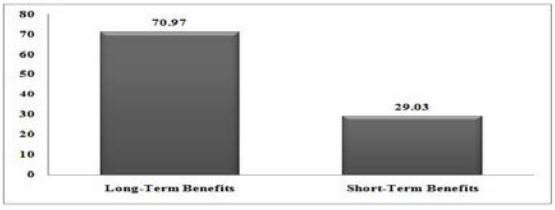


Fig.15 Planning Spans of Higher Education Institutions

In case of no implementation of SPI standards, we also tried to know the intent of the institutions if they want to initiate with it. We asked "Is your institution interested to implement software process improvement standards in your existing running software?" The interest rate measuring question was replied with Yes by 98.7% people and No came from 1.3% people. Almost, all the institutions want to apply them but there must be some shortfalls that hold them back. The results of this question are given in graphical form in **(Fig.16).**

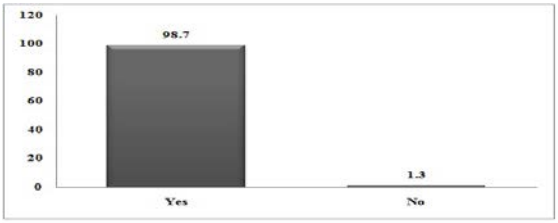


Fig.16 Intentions for the Implementation of SPI Standards in the Running Software

4. DISCUSSION

The people having software development experience of 5 years or more are less in number. The average experience people are in majority. The institutions may not afford highly experienced people for they cost them much. Therefore, institutions should ponder over to seek

the solution to acquire SPI programs at sufficient costs. In our country, the certified software developers and non-certified ones work together at the same scales. The professionally educated and trained software developers also lack knowledge in these two factors then what could be expected from the non-professionally trained people working with computers in the institutions. Hence, the recruitment should be fair, particularly in such technical fields so that people having specialization should come to their proper places and the working performance and environment will also be improved. In addition to this, the institutions should have awareness programs of SPIs for their employees so that they can benefit the institutions on behalf of their standards that they may learn in such awareness programs. Lack of interest in the improvement of development causes worsening situations in SPIs. The interest leads to the trial and we find 83% institutions trying for improvements. The success rate is still vague but such trial ratio shows that there is interest for improvement and there might be some other factors embedded in the success-way of this trial.

Apart from technical concerns, the institutional issues are also affective in this regard. Though, the question was asked about the satisfaction, it contained many aspects of the organizational and personnel behavior and response. The high satisfaction is a good thing but may not be good for the latest standards because people are traditional and may be highly satisfied with the archaic systems. The less or average satisfaction proves the gap between the organization and the employee or a gap between the level of management. The satisfaction will be gained when employees and practitioners are consulted or trained.

The maximum of 25% is found which like improvement of the software products. The other reasons for improvement do not likely show the interest for quality but for some other purposes like reducing costs, time etc. The factors of interest and compulsion are found in the natures of the reasons for improvements. Though, interest remains highest of all but the rate is not that much high to be appreciated for only 25% institutions are found in this category. The remaining 75% may or may not have interest in it but compulsions or requirements. Meeting the requirement is also appreciable when cutting costs is the most focused thing in the institutions.

Most of the people think that success is bound to the experienced staff only. But where that experience does come from? If the majority of people does not follow SPIs how will it come possible to have experience and from where? Apart from the institution politics, we may state that no critical factor is less affecting the SPI. People have their different opinions according to their approaches. Here, we may also form the basis of our research that people whether professionally or unprofessionally trained have cynical views about SPIs. All these issues lead to form the notion that SPI trainings, awareness and motivational programs are the keys to the success.

5. CONCLUSION

The issue that motivated us to initiate this research was the disappointing performance of some software applications, which are run in the higher education institutions of upper Sindh. The quality of these software products is not satisfactory according to the international SPI standards. The survey was conducted through the questionnaires that inquired about the causes and effects of the SPI standards. Following standards is mandatory for the software developers to ensure the validity and reliability of the developed products. The survey produced the results containing negative responses about SPI implementations. The post analysis of survey discovered that most of the software products are developed taking no international standards into consideration. Low quality of software allows many complications and problems to grow at micro and the macro level as well. These problems include misuse of information, loss of data and record, low quality performance and inappropriate management of information.

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