Sudan University of Science and Technology
College of Graduate Studies
College of Computer Science and Information Technology

Tailoring Software Process Improvement Models for Software Enterprises in Sudan

تفصيل نماذج تحسين عمليات البرمجيات

بشركات البرمجيات السودانية

A Thesis Submitted in Partial Fulfillment the Requirement of the Master Degree in Computer Science (Software Engineering Track)

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الآية

قال تعالي :

"فَبَدَأَ بِأَوْعِيَتِهِمْ قَبْلَ وِعَاءِ أَخِيهِ ثُمَّ اسْتَخْرَجَهَا مِن وِعَاءِ أَخِيهِ ۚ كَذَلِكَ كِدْنَا لِيُوسُفَ ۖ مَا كَانَ لِيَأْخُذَ أَخَاهُ

فِي دِينِ الْمَلِكِ إِلَّا أَن يَشَاءَ اللَّهُ ۚ نَرْفَعُ دَرَجَاتٍ مَّن نَّشَاءُ ۗ وَفَوْقَ كُلِّ ذِي عِلْمٍ عَلِيمٌ "

صدق الله العظيم

سورة يوسف الاية (76)

DEDICATION

….. To My father, who taught me that the best kind of knowledge to have is that which is learned for its own sake.

…… To My mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

…. To My beloved brother and sisters.

…. My friends who encourage and support me,

All the people in my life who touch my heart,

I dedicate this research.

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I would like to express my sincere appreciation to my supervisor Dr. Nisreen Beshir Osman ; who had afforded and guided me with all the needed instructions and information to complete the research and it was really great honor for me to work under her supervision.

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I would like to take this opportunity to say warm thanks to all my beloved friends, who have been so supportive along the way of doing my thesis.

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Because of their unconditional love and prayers, I have the chance to complete this thesis.

ABSTRACT

The majority of software development organizations all over the world are small enterprises. Successful implementation of SPI methodologies in small software enterprises (SEs) is generally not possible because such organizations are not capable of investing the cost of implementing these programs and limited resources. Software Process Improvement (SPI) activities have been reported to result in remarkable improvements in the quality of software, reduced time to market and increased productivity . The main goal of the research is to propose a model for small software enterprise, such as the enterprises working in Sudan. To develop the model, An extensive literature survey of software process improvement methodologies in SMEs, and an investigation of software development market in Sudan. The proposed model tailors the existing software processes to suite the special characteristics of the companies in Sudan. The Model used a designing questionnaire to measures the readiness of Sudanese software enterprises for implementation SPI in practices such as (initial, management and improvement). The data was collected from three small software Sudanese -based companies, and analyzed. The result of the analysis showed that the three companies at capability maturity less than improvement level. Which means that they do not follow any software process improvement standards. Both company (B&C) at the proposed model level-1 (Initial), Company (A) needs to implement the proposed model from level-1. The contribution of the research is the benefit for stakeholders of SPI projects in small companies special Sudanese software companies. The proposed model could be applicable in case companies are having trouble in initiating SPI or have concerns about the cost of implementing SPI.

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المستخلص

غالبية منظمات تطوير البرمجيات في جميع انحاء العالم هي منظمات صغيرة . نجاح تنفيذ منهجيات تحسين عملية البرمجيات في شركات البرمجيات الصغيرة هو عادة غير ممكن لان هذه المنظمات ليست قادرة على استثمار تكلفة تنفيذ هذه البرامج بالاضافه الى محدودية الموارد . أنشطة تحسين عملية البرمجيات تؤدي الى تحقيق تحسينات ملحوظه في جودة البرامج ، وتقليل الوقت اللازم للتسويق وزيادة الانتاجيه. الهدف الأساسي من الرسالة هو إقتراح نموذج للمشاريع البرمجيات الصغيرة كمثال لها شركات البرمجيات العامله بالسودان.لتطوير النموذج تم دراسة واسعة للنماذج السابقة المناسبه لشركات الصغيره كأول خطوه ثم عمل فحص لشركات تطوير البرمجيات السودانية العامله في السوق .تم تصميم النموذج بصوره تناسب خصائص شركات البرمجيات السودانية.استخدم النموذج المقترح إستبانه صُممت لقياس جاهزية الشركات للتطبيق العملي لبرامج تحسين عمليات البرمجيات . جُمعت البيانات من ثلاث شركات برمجيات سودانية وحُللت البيانات . نتائج التحليل أظهرت ان الشركات الثلاث في قدرة النضج أقل من مستوى التحسين وهذا يعني أن هذه الشركات لاتتبع إي معيار من معايير تحسين عملية البرمجيات ، كل من الشركة (ب،ج) هي في المستوى القدرة الاول من النموذج المقترح ، شركة (أ) تحتاج الى تنفيذ النموذج المقترح من أول مستوى . مساهمة البحث هو مفيد لأصحاب المصلحة في مشاريع الشركات الصغيرة بصوره خاصه شركات البرمجيات السودانية ونتائجه قابله للتطبيق خصوصاً في الحالات التي تواجه فيها الشركات صعوبه في بدء تطبيق برنامج تحسين عملية البرمجيات أو لديهم مخاوف بشأن تكلفة تنفيذ برنامج تحسين عملية البرمجيات.

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List of Abbreviations

SPI	Software Process Improvement
OWPL	Observatoire Wallon des Pratiques Logicielles The name acronym of the initial project
ISO	International Organization for Standardization
CMMI	Capability Maturity Model Integration
CMM	Capability Maturity Model
SE	Small Enterprises
SME	Small and medium-sized enterprises
UML	Unified Modeling Language
SPICE	Software Process Improvement and Capability dEtermination

Chapter One: Introduction

Chapter One: Introduction

1.1. Introduction

The software industry is an important economic activity in industrial countries [22]. Nowadays the investment in this field measured in millions of dollars, the IT organizations varies in their size and role[22]. An area of concern to IT organizations is implementing and adopting Software Process Improvement (SPI) models[22].

Software production in Sudan is very limited and the percentage is about 2% of total market sales, 80% of the companies have small resources and have about 2-5 staff members[13].these factors affect to apply software processes improvement of software process improvement standards affected negatively on their products.

In Small and Medium-size Enterprises (SMEs), Software Process Improvement (SPI) deployment approaches require special concerns due to some constraints regarding material and human resources [23].In order to assure their survival in the increasingly competitive market, it is necessary to overcome these difficulties and improve the productive process [23].

Most of the software developers in small companies believe the software process improvement and software process standard make their job more complex. This is due to many reasons firstly most of these models are developed to meet the needs of organizations in different market and different environments and they do not consider the characteristics of small companies. Secondly, the number of staff member assigned to each project is less than the number of staff that assumed in these models[13]. Finally , the Sudanese software companies do not have staff members for quality insurance and the successful of developed software is depend on the experiences of software developers[13].

The existing literature shows a strong need to new technique or method for Software process improvement tack into account the characteristic and requirements of Sudanese software companies. Moreover, this study is going to propose a simple, efficient and inexpensive methodology aim to helps software developer and project managers in Sudanese companies to guarantee success of software quality for their products.

1.2 Problem Statements

The problem arises on how can Tailoring software engineering methods, techniques, best practices, and tools appropriate for Sudanese software companies to improve software quality and productivity without introducing unacceptable overhead?

1.3 Research Aim and Objective

This study aims Tailoring standard for software process assessment and improvement for Sudanese software companies.

1.4 Outcomes and deliverables

1- Increase awareness of the importance of developing and improving quality in small enterprise.

2- Contribute to the organization and arrangement of working with in software enterprises.

3- Enhance the company's survival in the market.

4- Enhance customer's satisfaction.

Chapter Two:
Literature Review

Chapter Two: Literature Review

2.1 SPI Previous Studies worldwide (K-model)

2.1.1 Introduction

The guideline of software process quality certification consists of project and formation level, and it developed to satisfy the investigation of software process quality capability and improvement at the same time [25].

The guideline of software process certification can easily apply to the process improvement of domestic software business by compositing to be congenial to the korea environment, and structuring the traits of essential software development and organization management [25].

2.1.2 Structure of K-model

The guideline of software process quality certification has been constituted by certification degree as a result on the base of the essential evaluation element of core activity necessary for systematic performance to software development project[25].

Software business and software process capability level are to decide the certification result degree by investigating the activities suggested as the valuation factor of the process certification guideline to the performance activities in the course of the project development and management process[25].

2.1.3 Level of K-model

2.1.3.1 Level1: Initial

This is the necessary level of improving the process capability in the situation of the performance level of special project, or quality, cost, the appointed date of delivery because project performances can't operate stably, in the situation of the high probability that can't satisfy the expecting purpose regardless of success or failure of project [25].

2.1.3.2 Level2: Good

The process is the capability level to successfully perform the project by developing and controlling project, to be established in the necessary project level to perform individual project [25].

2.1.3.3 Level3: Very good

This is the possible capability level to perform project of consistent quality level by solving the fundamental reason of happening matters in the course of improving process of formation level through the quantitative process management by defining process system of formation [25].

2.2 Previous study about SPI in SMEs in Sudan

2.2.1 Study published by A.M. Abdulgader about Problems and Future Trend of Software Process Improvement in some Sudanese software organizations.

The study was conducted for 28 companies of different size and specialties, interview the software experts to observe how these organization can improve their software process and then design a questionnaire in order to show the relationship between Sudanese software organizations and software process improvement standards.

The result of study concluded that the most of the Sudanese software companies do not follow any software process improvement standards and identified the problems faced by these organizations during the implementation of software process improvement standards and shows the ability of these organizations to implement the software process improvement standards [13].

The methodology of this study base on questionnaire that distributed among 28 respondents [13]. The organizations chosen to complete the questionnaire are Sudanese organizations and 78% of these organizations from an information technology organization type and 22% of the respondent were mainly from telecommunications organization type [13].

Summary of the study:

More than 90% of the respondents think implementation of software process improvement standards increase software quality. But, still most of Sudanese software organizations are not implementing any software process improvement standards. However , most respondent are able to implement software Process improvement standards. Respondents agreed that adopting software Process improvement standards for a small-scale project will result in an increase in cost. Conversely, when it came to medium and large-scale project the costs started to decrease for adopting software process standards [13]. 57.1% of the respondents for small-scale project believe that there is a decrease in quality when adopting software process improvement standards [13].

Although, the 92.9% of the respondents of medium-scale project believe that there is a high increase in quality when adopting software process improvement standards and all respondents believed that there is a high increase in quality when adopting software process improvement standards for large-scale projects [13]. The most common problems experienced while implementing software process improvement standard for different kinds of software organizations are: lack of skilled people who are unable to follow standards, lack of top management support, lack of customer collaboration, project size/complexity, project Team size and the cost [13]. 35.7% of the respondents believe other SPI model is the suitable of the software process improvement standards for the different kinds of organizations [13].

This result because the most respondents are small organizations and the respondents tack in their account Sudanese organization properties[13].

2.2.2 Study published by Aiman M. Solyman about Project management and software quality control method for small and medium enterprise

The study aims to find solutions for problems that faced small and medium-sized companies in the field of software development on the Sudanese market particular and generally developments country because whole target faced the challenges and problems [24] .

The solution is to development methodology for project management and software quality, the main characteristics is simple, efficient and inexpensive use to merge ISO/IEC 25010 standard with a CMMI model level II [24].

Apply this methodologies on two track first one called "Customer responsibility" the second track called "Supplier responsibility" which one summarizes customer and supplier responsibility during whole development life cycle of product from the initial stage (writing functional and non-functional requirements – technical project scope) until deliver project [24]. Abbreviated development cycle in three main stages to simplify as follows:

1. The initial stage, at this stage submission two main reports the first one software requirements specification (functional requirements and non-functional requirements) the second report is technical project scope (cost and time estimation, quality, risk management, ect.) each report written in three copies (draft – proposed - approval) and there are several meetings between customer and project needs, at the same stage after knows the main functional, nonfunctional requirements and feature for proposal project customer must be paid a percentage of the total cost and specify the payment mechanism[24].

2. Development stage, divided into three main sub-stages (design, code writing, testing "system evolution") as follows:

    I. Design, at this phase must be delivered model or sketch to customer about proposal design shows shape of the future system, discussed between customer and project manager to reach a final agreement and then implement the final design [24].

    II. Code writing, at this phase start to implement project architecture and components, code must be written on clear standards and defensive programming concepts to avoid a long list of problems and challenges that will be facing product during operation [24].

III. Testing, at this phase are preformed simple and quick test before delivery project, protection and security must be the most importance test at this phase and then hold a meeting between development team members to make sure the project has been developed correctly, without errors according to customer expectations knows bet a presentation[24].

3. Review and delivery, at this stage must be delivered an initial version of the project to customer to be reviewed and express an opinion about the system performance using simple form called "Check List" and then hold a meeting between customer and project manager to discuss the checklist and then re-work after complete work must be inform customer to re-check the list again and makes sure the system work correctly, without errors according to his expectations, finally sign a document known "Sign-off project" as acknowledgment about that and pay the remaining cost before receipt of the final version[24].

2.3 Software Process Improvement

2.3.1 Introduction

Software Process Improvement (**SPI**) is a set of activities that will lead to a better software process, and thus higher quality software delivered in a more timely manner[1].**SPI** implies that elements of an effective software process can be defines in an effective manner an existing organizational approach to software development and a meaningful strategy for improvement can be defined [4]. The **SPI** strategy transforms the existing approach to software development into something that is more focused, more repeatable, and more reliable [4].

The main Objectives of Software Process Improvement are:-

☐ To understand the current state of software engineering and management practice in an organization[11].

☐ To select improvement areas where changes can yield the greatest long-term benefits[11].

☐ To focus on adding value to the business, not on achieving someone's[11].

☐ To prosper by combining effective processes with skilled, motivated, and creative people[11] .

2.3.2 Process Improvement Cycle
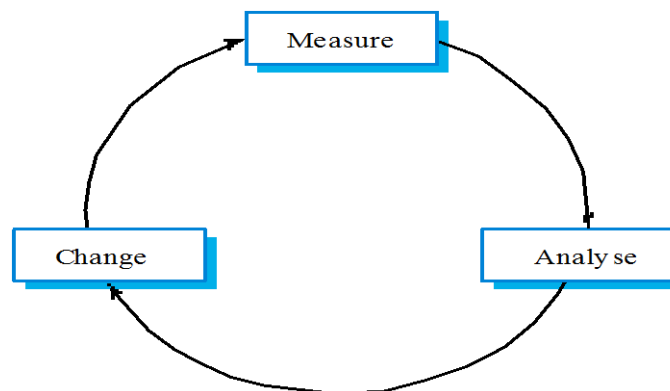
Figure2-1: Process Improvement Cycle

➤ **software measure**

>   **Measure:** something that provides a quantitative indication of the extent, amount, dimensions, capacity, or size of some attribute of a product or process [3].For example, the number of errors uncovered in a single review is a measure [3] .

>   **Measurement:** is the assignment of numbers to objects or events according to rule [6] .The rule of assignment can be any consistent rule [6] .The only rule not allowed would be random assignment, for randomness amounts in effect to a non-rule [6] . Measurement is "the act or process of assigning a number or category to an entity to describe an attribute of that entity"[6].

There are two types of measurements:

>   ☐ **Direct measures** Direct process measures include cost and effort direct product measures include lines of code (LOC), execution speed, memory size, defects per unit time [3].

>   ☐ **Indirect measures** Indirect product measures include functionality, quality, complexity, efficiency, reliability, maintainability [3].

➤ **Software measurement and analysis**

Measurement and analysis involves gathering quantitative data about products, processes, and projects and analyzing that data to influence the actions and plans[7].

Measurement and analysis activities allow the followings:

>   ☐ **Characterize**: understanding of the processes, products, resources, and environments and to establish baselines for comparisons with future assessments[7].

>   ☐ **Evaluate**: This enable to assess achievement of quality goals and to assess the impacts of technology and process improvements on products and processes[7].

☐ **Predict** by understanding relationships among processes and products and building models of these relationships, so that the values to observe for some attributes can be used to predict others [7]. establish achievable goals for cost, schedule, and quality so that appropriate resources can be applied **[7]** .

☐ **Improve** Measures of current performance give baselines to compare against, so that can judge whether or not improvement actions are working as intended and what the side effects may be [7]. Good measures also help communicate goals and convey reasons for improving [7]. This helps engage and focus the support of those who work within processes to make them Successful [7].

2.3.3 The Process Maturity Framework

After two decades of unfulfilled promises about productivity and quality gains from applying new software methodologies and technologies, industry and government organizations are realizing that their fundamental problem is the inability to manage the software process **[4]**. The benefits of better methods and tools cannot be realized in the maelstrom of an undisciplined, chaotic project **[4]**. In many organizations, projects are often excessively late and double the planned budget**[4]**.In such instances, the organization frequently is not providing the infrastructure and support necessary to help projects avoid these problems **[4]** .

➢ **Immature Versus Mature Software Organizations**

In an immature software organization, software processes are generally improvised by practitioners and their management during the course of the project [12].The immature software organization is reactionary, and managers are usually focused on solving immediate crises (better known as fire fighting) [12]. Schedules and budgets are routinely exceeded because they are not based on realistic estimates [12].When hard deadlines are imposed, product functionality and quality are often compromised to meet the schedule[12].

In an immature organization, there is no objective basis for judging product quality or for solving product or process problems [12].Therefore, product quality is difficult to predict [12]. Activities intended to enhance quality such as

reviews and testing are often curtailed or eliminated when projects fall behind schedule[12].

On the other hand, a mature software organization possesses an organization-wide ability for managing software development and maintenance processes[12]. And work activities are carried out according to the planned process [12]. Improvements are developed through controlled pilot-tests and/or cost benefit analyses[12]. Roles and responsibilities within the defined process are clear throughout the project and across the organization[12].

In a mature organization, managers monitor the quality of the software products and customer satisfaction[12].There is an objective, quantitative basis for judging product quality and analyzing problems with the product and process[12].Schedules and budgets are based on historical performance and are realistic, the expected results for cost, schedule, functionality, and quality of the product are usually achieved[12].In general, a disciplined process is consistently followed because all of the participants understand the value of doing so, and the necessary infrastructure exists to support the process[12].

2.3.4 SPI Processes

The are five processes in SPI

- ➢ The SPI Process-I
- ☐ Assessment and gap analysis
- ☐ Assessment examines a wide range of actions and tasks that will lead to a high quality process
- ☐ Consistency. Are important activities, actions and tasks applied consistently across all software projects and by all software teams?
- ☐ Sophistication. Are management and technical actions performed with a level of sophistication that implies a thorough understanding of best practice?
- ☐ Acceptance. Is the software process and software engineering practice widely accepted by management and technical staff?
- ☐ Commitment. Has management committed the resources required to achieve consistency, sophistication and acceptance?
- ☐ Gap analysis—The difference between local application and best practice represents a "gap" that offers opportunities for improvement [4]

➤ The SPI Process—II

Education and Training

Three types of education and training should be conducted:

☐ **Generic concepts and methods** Directed toward both managers and practitioners, this category stresses both process and practice [4]. The intent is to provide professionals with the intellectual tools they need to apply the software process [4]. Effectively and to make rational decisions about improvements to the process [4].

☐ **Specific technology and tools** For example, directed primarily toward practitioners, this category stresses technologies and tools that have been adopted for local use, if UML has been chosen for analysis and design modeling, a training curriculum for software engineering using UML would be established [4].

☐ **Business communication and quality-related topics** Directed toward all stakeholders, this category focuses on "soft" topics that help enable better communication among stakeholders and foster a greater quality focus[4].

➤ The SPI Process—III
☐ Selection and Justification
☐ choose the process model that best fits your organization, its stakeholders, and the software that you build
☐ decide on the set of framework activities that will be applied, the major work products that will be produced and the quality assurance checkpoints that will enable your team to assess progress
☐ develop a work breakdown for each framework activity (e.g., modeling), defining the task set that would be applied for a typical project
☐ Once a choice is made, time and money must be expended to install it within an organization and these resource expenditures should be justified[4].

➢ The SPI Process—IV
  ☐ Installation/Migration
  ☐ actually software process redesign (SPR) activities. "SPR isconcerned with identification, application, and refinement of new ways to dramatically improve and transform software processes[4] .

➢ The SPI Process—V

Evaluation

  ☐ assesses the degree to which changes have been instantiated and adopted
  ☐ the degree to which such changes result in better software quality or other tangible process benefits, and the overall status of the process and the organizational culture as SPI activities proceed
  ☐ From a qualitative point of view, past management and practitioner attitudes about the software process can be compared to attitudes polled after installation of process changes[4].

2.3.5 Risk Management for SPI

manage risk at three key points in the SPI process:

  ☐ prior to the initiation of the SPI roadmap
  ☐ during the execution of SPI activities (assessment, education, selection, installation), and
  ☐ during the evaluation activity that follows the instantiation of some process characteristic[4].

In general, the following categories can be identified for SPI risk factors:

  ☐ budget and cost
  ☐ mission and goals
  ☐ process stakeholders
  ☐ schedule for SPI development
  ☐ SPI project management and SPI staff [4]

2.4 Process improvement in Small Enterprise

2.4.1Definition of Small Software Enterprise

The concept of the small and medium-sized enterprise (SME) was clearly define in Europe (fewer 250 employees or with a turnover of less than or equal to 50 million Euro dollars) and in United States (fewer than 500 employees) [10]. While At the time, there was no official definition of a SE in Africa [10].

Table 2-1 Refer to the definition of SMEs in Africa (Egypt) [9]

Criteria	Micro	Small	Medium
No. of employees	< 10	10-50	51-99
Capital	<LE 50.000	LE 50.000 –LE 1 Million	LE 1Million – LE 5 Million

2.4.2 Characteristics of Small Software Organization

Small companies represent up to 85 percent of all software organizations. However, to persist and grow, small software companies need efficient, effective software engineering solutions[8]. People often believe that good practices and solutions are expensive, time consuming, and targeted more toward large organizations, and therefore difficult to apply in small companies[8].

Small organizations have some advantages over larger ones[8]. For example organizational politics is reduced, due to fewer staff and clearer central control[8].

A smaller number of staff may also reduce communication and coordination overhead in deploying new processes [8].

2.4.3 Organizational challenges

Large and small software development companies face similar software engineering challenges[8].They need to manage and improve their software processes, deal with rapid technology advances, maintain their products, operate in a global software environment, and sustain their organizations through growth[8].However, they often require different approaches because of specific business models and goals, market niche, size, availability of (financial and human) resources, process and management capability, and organizational differences, among other things [8].

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2.4.4 Previous work done in this area worldwide:

In order for process improvement to better respond to industry expectations there needs to be a value-centric thinking about processes so that all processes in the organization are contributing to the creation of value for the customer and for the organization[15].To achieve this, organization's strategic goals need to be aligned with process goals on operational level so that all work contributes to the strategic goals of the organization[15]. Similarly, the performance measurement system needs to be revised to direct efforts toward reaching the broad goals of the cross-functional processes rather than small tasks and compliance to set rules[15].

2.4.5 Process Improvement for the Small and Agile

There are a couple of reasons to become more agile when doing process improvement [14]. From a business point of view it is more and more important to be able to adopt process improvement programs to the changing business needs, and to be able to deliver more value to the business [14]. This included making the value visible, which supports discussions on what value has been brought already, and what value can be expected from process improvement[14]. Another reason to become more agile was to engrain process improvement in the way of working within the organization[14]. Many organizations have or are adopting agile development methods, and use techniques like retrospectives to continuously improve on a team level; it feels natural to adopt similar mechanisms for process improvement programs. Finally, since there are almost always limitations in lead-time and money (available hours of the team and of the organization that need to adopt the changes), you have to work as efficiently as possible. Agile helps the improvement team to deliver quickly, and deliver maximum value with a limited budget [14].So altogether there are sufficient reasons, from a business point of view to adopt an agile way of working for process improvement[14].

The benefits of agile process improvement are:-

- □ Being able to deliver the right product with high quality, using frequent feedback
- □ Understanding the strengths & weaknesses of our processes, and the business value
- □ Efficient ways for professionals to work together in a dispersed team[14]

2.4.6 Software process improvement in Sudanese software organizations

Most of the Sudanese software companies do not follow any software process improvement standards [13].For this reason, normally these companies produce the software without high quality [13]. Furthermore, the low quality may be the cause of some problems such as unreliable software and high maintenance[13].

Chapter Three: Methodology

Chapter Three: Methodology

3.1 procedures resulted in the model

Any software process improvement plan requires a qualified statement about the current status of software development in the companies and a description of strengths and weaknesses identifying areas for improvement.

3.1.1 Software process improvement methodologies in SMEs

On the basis of a literature survey, we have selected the following two SPI methodologies which have been implemented in SMEs. Due to limited resources and the size of the organizations, an extensive, formal assessment of the software practices following defined comprehensive approaches like MESOPYME and OWPL model.

3.1.1.1MESOPYME

MESOPYME has been defined, taking into account a generic SPI model defined in four stages [2]. The key features of MESOPYME are as follows:

1-**Commitment to improvement.**
Its objective is to obtain the support of senior management to carry out the improvement project [2].

2-**Software process assessment.**
Its objective is to obtain strengths and weaknesses of the process assessed with respect to a software process model— CMM (Capability Maturity Model). From this assessment, processes (usually 1 to 3) to be improved are selected[2].

3-**Improvement solution.**
Its objective is to provide the needed infrastructure to carry out improvement (in selected processes), and to create the plan to follow in order to define and implement improvement in these selected processes[2]. The improvement solution stage is performed through the application of a generic set of components that we have called an Action Package. An Action Package is a general solution to a particular software process area that should be customized to a company, taking into account its business goals and assessment results [2]. An action package is implemented in some selected pilot projects [2].

4-**Institutionalize.**
Finally, improvement must be institutionalized [2].

3.1.1.2 OWPL: A Gradual Approach for Software Process Improvement in SMEs

This approach is based on a three-stage software process improvement framework [19].

1- Micro-assessment

At this stage, a very simplified questionnaire called the micro-evaluation is used to collect information about the current software practices in small structures and to make people aware of the importance of software quality aspects [19].

Micro-evaluation results are presented in a report written by an evaluator. It includes general recommendations and specific improvement actions prioritized with respect to the organization's context and goal [16].

2- OWPL evaluation

As micro-evaluation's main goal is to give a first analysis, an in-depth analysis is achieved through this step. OWPL is designed to quickly identify processes related to software development in need of improvement, and also, to help draw a simple action plan [17].

3- SPICE assessment

Bigger companies with medium/high quality level are eventually invited to undertake an ISO/IEC15504 or a CMMI evaluation if this appears appropriate [19].

3.1.2 Data Collection &Analysis (questionnaire)

1. Introduction

The questionnaire is conducted as part of this study. The main goal of the research is to propose model for software enterprise, in this case is specifically to Sudan. The research aims to provide brief findings of the conceptual model and the recommendation for Sudan to improve software process in the future.

The goal of this questionnaire collected information to determine how prepared the companies were for SPI implementation, using an implementation the proposed model.

2. Data Collection Methods

The organizations in this study are small software enterprise in Sudan, this research uses a series of semi-structured questionnaire for data collection

The questionnaire questions are divided into two sections:
Section One: Respondent background

Section two: Proposal model practices:

1. **Project Initial**

2. **Project management**

3. **Project improvement**

The following set of the questions and their scope were finalized and summarized, as in Table

Table 3-1 questions and their scope

Q. No	Section No	Questions	Scope
1	**Section One: Respondent background**	Which best describes your current position?	☐ Leader ☐ Manger ☐ Software engineer ☐ Technical member ☐ Other
2		Have you received any software process improvement – related training?	Training & Educate in software process improvement
1	**Section Two: Proposed model practices:**	Are you aware and have the knowledge to start SPI?	☐ Experience and ☐ awareness of team members for improvement in software Industry
2	**1. Initial**	Is there a readiness to proceed with SPI?	☐ Launch the SPI program by building an understanding ☐ An awareness of the costs and benefits.
3		Did you create a proposal for a SPI program, outlining the needs for SPI and resource requirements?	☐ Create a proposal for a SPI program ☐ Commit the resources necessary. ☐ Recommend a schedule and infrastructure to manage the program

4		Do you know information on the current strengths and opportunities for improvement in the organization?	Understand the working of the current processes and the organizational interactions and how they contribute to the organization's business.
1	**Proposal model practices: II. management**	Is a SPI strategic action plan will provide guidance and direction to the SPI program in the years to come?	The SPI strategic action plan, which will be developed after the baselining activities are complete, is critical: it is needed to provide clear guidance for the various process improvement actions that will be taken over the next few years.
2		Do you integrate the SPI strategic action plan with the organization's business plan, mission, and vision?	Relationship between SPI strategic action plan and organization's vision.
3		Do you develop improvements and solutions to the process issues found during the baselining phase. The key processes and/or problems discovered during the previews phase?	□ investigate the problem and develop a solution(problem orientation) □ plan the improvement project.
1	**Proposal model practices: III. improvement**	Do you use lessons learned from previous phases into SPI approach (**Project Initial phase)**?	kept track of the lessons learned from each of the SPI activities in Initial phase
		Incorporate improvements into the SPI processes?	You will now apply them during the improvement phase to make the SPI process work better.
2		Do you use lessons learned from previous phases into SPI approach (**Project management phase**) ?	kept track of the lessons learned from each of the SPI activities in management phase
		Incorporate improvements into the SPI processes?	You will now apply them during the improvement phase to make the SPI process work better.

3		Do you evaluate sponsorship and commitment?	Has the infrastructure been able to obtain and allocate sufficient resources to ensure timely accomplishments?
4		Using SPI has a value to organization?	Benefit of Using SPI in organization
5		Do you create a guide the organization through the next cycle?	Does the organization to continue in the SPI program in future.

3. The Case Studies

The three companies in our case study are called "Company A", "Company B" and "Company C". After describing these companies below:

3.1 Company A is a small Sudanese -based company that provides hardware and software services. The company employs fewer than 20 professionals. Company A has been in existence for more than 3 years.

3.2 Company B is a small Sudanese -based company that provides software services. The company employs fewer than 30 professionals. Company B has been in existence for more than 3 years.

3.3 Company C is a small Sudanese -based company that provides software services. The company employs fewer than 45 professionals. Company C has been in existence for more than 4 years.

4. Sample size

Data was collected from survey questionnaire that was distributed to a total of 70 citizens between the period of June and July2016. from70 questionnaires distributed, 65 responses were received .of the 65 completed and received, 9 questionnaires were discarded (because the respondents gave more than one answer to a question that expected only one answer)and less questions were unanswered. This meant that, from the final sample of 65questionnaire, 56 usable responses were obtained and used for all subsequent analysis.

5. Reliability of measurements

Table 3-2: Reliability of measurements (Level1: Initial)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
The knowledge and awareness to start SPI	7.96	3.490	.362	.593
Readiness to proceed	8.29	3.735	.370	.580
proposal for a SPI program , needs and resource requirements	8.04	3.817	.415	.549
Information on the current strengths and opportunities for improvement	7.59	3.556	.486	.498

Reliability Coefficients :**Alpha = .63**

Table 3-3: Reliability of measurements (Level2: management)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
strategic action plan & direction to the SPI program	4.00	1.164	.490	.439
strategic action plan & organization's business plan	5.25	1.973	.504	.471
Solution of problems and improvements	4.79	1.808	.351	.613

Reliability Coefficients :**Alpha = .62**

Table 3-4: Reliability of measurements (Level3: Improvement)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Lessons learned from previous phases (Project Initial phase)	9.43	5.049	.673	.594
Incorporate improvements into the SPI	9.46	5.235	.612	.611
Lessons learned from previous phases (Project management phase)	9.45	5.015	.719	.587
Incorporate improvements into the SPI	9.50	5.455	.536	.629
Evaluate sponsorship and commitment	8.70	5.124	.297	.671
Benefit of using SPI	7.93	4.104	.192	.832
change a guide the organization through the next cycle	9.50	5.345	.605	.617

Reliability Coefficients :**Alpha =.68**

Cronbach's coefficient alpha values were estimated to examine consistency of the data post-gathering, Cronbach's result varied between (.68) for level1 initial and (.62) for level2 management and (.68) for Level3 Improvement.

These values between high moderate reliability (from .50 to .70) according to hintons cut-off point of reliability (nunnally, 1978).

6. Demographic characteristics of the respondent

Table 3-5: Shown current position on the three companies
Relating to respondents current position in **company A** :(77.8%) of the 9 usable responses were software, while (22.2%) other.
Company B : (52.9 %) of the 17 usable responses were software, while (17.6%) team leader, (11.8%) technical, (5.9%) manger,(11.8%) other.
Company C : (60%) of the 30 usable responses were software, while (20%) team leader, (10%) technical, (6.7%) manger, (3.3%) other.

Table 3-5: Shows the current position on the three companies

	A		B		C	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Team leader	0	0.00	3	17.6	6	20.0
Manger	0	0.00	1	5.9	2	6.7
Software professionals	7	77.8	9	52.9	18	60.0
Technical	0	0.00	2	11.8	3	10.0
Other	2	22.2	2	11.8	1	3.3
Total	9	100.0	17	100.0	30	100.0
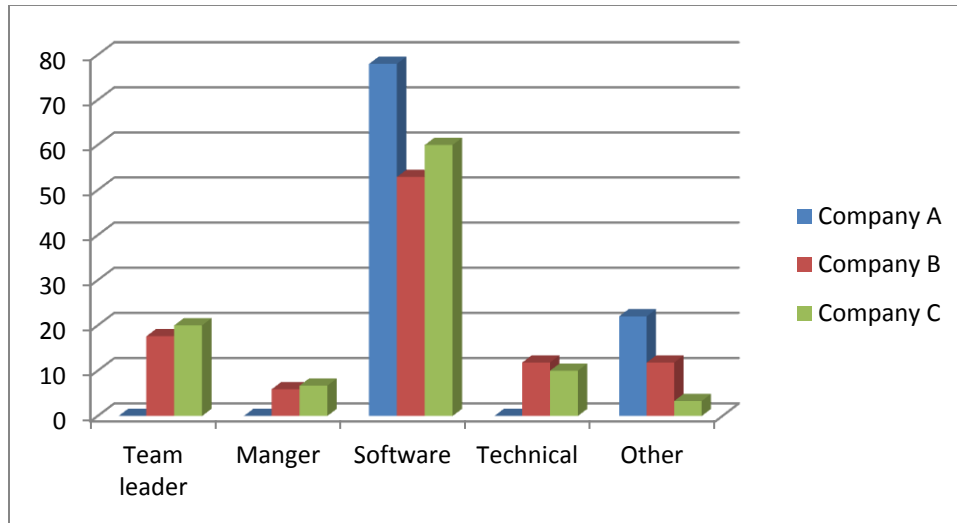
Figure 3-1: current position of respondent in Companies A, B, C

Table 3-6: Shown Training on the three companies

Company "A" :(22.2%) of the 9 usable responded with Yes, while (77.8%) responded No.

Company "B" :(29.4%) of the 17 usable responded with Yes, while (70.6%) responded No.

Company "C" :(23.3%) of the 30 usable responded with Yes, while (76.7%) responded No.

Table 3-6 Training on the three companies

	A		B		C	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	2	22.2	5	29.4	7	23.3
No	7	77.8	12	70.6	23	76.7
Total	9	100.0	17	100.0	30	100.0
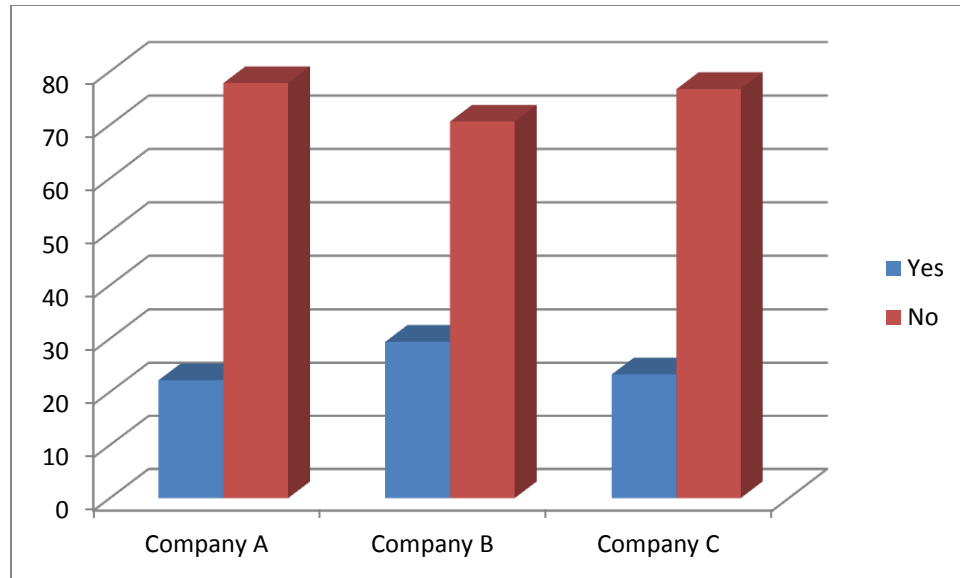
Figure 3-2: Trainings of respondent in Companies A,B,C

7. Descriptive Statistics for learn study

To determine how prepared the companies were for SPI implementation, by using mean and **"**central" value of Likert Scale for three level.

The mean is the average of the numbers: a calculated "central" value of a set of numbers.
To calculate: Just add up all the numbers, then divide by how many numbers there are.
(2.5)≡"central" value of Likert Scale of level-1 Initial

(2.5)≡"central" value of Likert Scale of level-2 management

(1.7)≡"central" value of Likert Scale of level-3 improvement

Table 3-7: Quantitative Statistics for Company A

	Number	Minimum	Maximum	Mean	Std. Deviation
Level1: initial	9	1.50	3.00	2.4	.45
Level2: Management	9	2.00	3.33	2.2	.45
Level3: improvement	9	1.14	2.29	1.6	.40

mean value of level-1, level-2 and level-3(initial, management & improvement) less than "central" value of Likert Scale.

Table 3-8: Quantitative Statistics for Company B

	Number	Minimum	Maximum	Mean	Std. Deviation
Level1: initial	17	1.75	4.00	2.8	.73
Level2: Management	17	1.00	4.00	2.1	.94
Level3: improvement	17	1.00	2.43	1.5	.44

mean value of level-1 (initial) greater than "central" value of Likert Scale, While mean value of level-2 and level3(management& improvement) less than "central" value of Likert Scale.

Table 3-9: Quantitative Statistics for Company C

	Number	Minimum	Maximum	Mean	Std. Deviation
Level1: initial	30	1.75	3.75	2.5	.53
Level2: Management	30	1.33	3.67	2.4	.50
Level3: improvement	30	1.00	2.29	1.4	.31

mean value of level-1 (initial) greater than "central" value of Likert Scale, While mean value of level-2 and level3(management& improvement) less than "central" value of Likert Scale.

8. Descriptive analysis of Responses

Table 3-10: descriptive analysis Level-1 for three companies (A,B,C)

		Company A			Company B			Company C	
Level 1: initial	**1- The knowledge and awareness to start SPI**								
	The knowledge	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Excellent	0	0.00		3	17.6		2	6.7
	Very good	1	11.1		3	17.6		7	23.3
	Good	2	22.2		3	17.6		4	13.3
	Accepted	3	33.3		5	29.4		12	40.0
	No knowledge	3	33.3		3	17.6		5	16.7
	Total	9	100.0		17	100.0		30	100.0
	2- Readiness to proceed								
	Readiness	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Agree	6	66.7		14	82.4		14	46.7
	Neutral	0	0.00		2	11.8		5	16.7
	Disagree	3	33.3		1	5.9		11	36.7
	Total	9	100.0		17	100.0		30	100.0
	3- proposal for a SPI program , needs for SPI and resource requirements								
	Proposal and need for SPI	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Very good information	0	0.00		4	23.5		4	13.3
	Good information	6	66.7		6	35.3		6	20.0
	Simple information	2	22.2		4	23.5		10	33.3
	Nothing	1	11.1		3	17.6		10	33.3
	Total	9	100.0		17	100.0		30	100.0
	4- Information on the current strengths and opportunities for improvement in the organization								
	information for improvement	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Very good information	2	22.2		3	17.6		5	16.7
	Good information	6	66.7		9	52.9		16	53.3
	Simple information	3	33.3		5	29.4		7	23.3
	Nothing	0	0.00		0	0.00		2	6.7

Table 3-11: descriptive analysis Level-2 for three companies (A,B,C)

		Company A			Company B			Company C	
level 2: Management	**1- Action plan provide guidance and direction to the SPI program in the years to come**								
	strategic action plan & direction to the SPI program	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Completed	0	0.00		1	5.9		7	23.3
	Average	1	11.1		4	23.5		9	30.0
	Simple	7	77.8		3	17.6		9	30.0
	No thing	0	0.00		6	35.3		3	10.0
	Don't know	1	11.1		3	17.6		2	6.7
	Total	9	100.0		17	100.0		30	100.0
	2- Integrate the SPI strategic action plan with the organization's business plan, mission, and vision								
	strategic action plan & organization's business plan	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Agree	3	33.3		9	52.9		6	20.0
	Neutral	2	22.2		2	11.8		6	20.0
	Disagree	4	44.4		9	52.9		18	60.0
	Total	9	100.0		17	100.0		30	100.0
	3- develop improvements and solutions to the process issues found during the baselining phase								
	Solution of problems and improvements	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Completed	0	0.00		1	5.9		1	3.3
	Part of this	1	11.1		4	23.5		11	36.7
	Simple	7	77.8		6	35.3		15	50.0
	No thing	1	11.1		6	35.3		3	10.0
	Total	9	100.0		17	100.0		30	100.0

Table 3-12: descriptive analysis Level-3 for three companies (A,B,C)

		Company A			Company B			Company C	
level 3: Improvement	**1- used lessons learned from previous phases into SPI approach(Initial phase)**								
	Lessons learned from previous phases (Project Initial phase)	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Yes	3	33.3		4	23.5		6	20.0
	No	6	66.7		13	76.5		24	80.0
	Total	9	100.0		17	100.0		30	100.0
	2- Incorporate improvements into the SPI processes								
	Incorporate improvements into the SPI	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Yes	2	22.2		4	23.5		5	16.7
	No	7	77.8		13	76.5		25	83.3
	Total	9	100.0		17	100.0		30	100.0
	3-used lessons learned from previous phases into SPI approach(management phase								
	Lessons learned from previous phases (Project management phase)	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Yes	3	33.3		4	23.5		5	16.7
	No	6	66.7		13	76.5		25	83.3
	Total	9	100.0		17	100.0		30	100.0
	4- Incorporate improvements into the SPI processes								
	Incorporate improvements into the SPI	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Yes	2	22.2		2	11.8		5	16.7
	No	7	77.8		15	88.2		25	83.3
	Total	9	100.0		17	100.0		30	100.0
	5-Evaluate sponsorship and commitment								
	Evaluate sponsorship and commitment	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Yes	4	44.4		4	23.5		4	13.3
	Neutral	1	11.1		6	35.3		23	76.7
	No	4	44.4		7	41.2		4	13.3
	Total	9	100.0		17	100.0		30	100.0
	6- Benefit of using SPI								
	Benefit of using SPI	Frequency	Percent		Frequency	Percent		Frequency	Percent
	Complete gains	2	22.2		9	52.9		8	26.7
	Medium gains	1	11.1		5	29.4		6	20.0
	Few gains	2	22.2		1	5.9		6	20.0
	No thing	4	44.4		2	11.8		10	33.3
	Total	9	100.0		17	100.0		30	100.0

7- change a guide the organization through the next cycle							
change a guide	Frequency	Percent		Frequency	Percent		Frequency	Percent
Yes	3	33.3		4	23.5		2	6.7
No	6	66.7		13	76.5		28	93.3
Total	9	100.0		17	100.0		30	100.0

3.1.3 Investigation of market

For most organizations, Companies and increasingly for individuals, software has become an essential element[20].Software as well as business systems are a key component of telecommunications, defense, transport, and medical systems[20].Software also plays a strategic role enabling organizations and Companies to meet challenges of flexibility and to reduce costs and to maintain quality[20]. With the growing use of internet and mobile technologies, and embedded software in consumer products, individuals are also more reliant on software; it has become 'woven into the threads of our daily lives [20].Today, software is an intrinsic part of different commodities such as cars, watches, televisions and many other products used every day [20].

Development of new systems or products is often carried out by using the experience and intuition of management and technical personnel [20].It is clear that there are some requirements are to be found in an enterprise or a company that working in the field of Software Development to meet international standards[20].A good enterprise or company usually:

☐ Has a financial, organizational, and human resource necessary to manage variety of activities.

☐ Can maintain software improvement process.

☐ Can use effectively the past experience with methodologies to foster improvement.

☐ Can acquire knowledge about best practice adoption through various cooperative strategies with other Companies and institutions experienced in software process improvement [20].

3.1.4 Tailoring SP to Sudanese organization:

The Sudanese software development companies have the following characteristics. The proposed model is going to tailor the existing software processes to suite the special characteristics of the companies in Sudan.

1. Company's size
Software Development Companies in Sudan are classified to be of small size compared with international Companies[20].

2. Financial Ability

The establishment of Software Development Company depends basically on financial ability rather than well trained and expert developers [20].the majority of the Software Development Companies in Sudan lack financial, organizational, and human resource necessary to manage and improve variety of activities[20].

3. Age of Companies

Most companies in Sudan are a relatively young Hence, it is obvious that Software Development in Sudan do not have enough experience to enhance the process of Software Development[20].

4. Proportion of Staff Qualifications:
The proportion of graduate staff (staff without post graduate qualifications) is quite high [20].

3.1.5 Proposal Model

3.2 The Proposed Model

3.2.1 Introduction

The Proposed Model helps an organization to improve its processes and to determine its capability for certain requirement. First collected information about organizations processes after that analysis results, from business point of view, identify strengths, weakness and risks inherent in the processes.

By this, analysers are able to determine whether the processes are effective, and to identify significant causes of poor quality, or over runs in time or cost. After recognizing these kinds of issues, managers can prioritise improvements to processes . Process capability determination analyses the proposed capability of selected processes against a target process capability profile. By this, it tries to find out the risks involved in a project, if the project is run with the analyzed processes .

The objectives of the model

- ☐ To develop a working draft for a standard for software process assessment
- ☐ To support improvement planning with suitable and reliable results
- ☐ To identify, in the assessed organization, process strengths and weaknesses.
- ☐ To support the achievement of the organization's goals by planning improvement actions.

3.2.2 The main features of the model

The proposed model is divided into two dimensions: a process dimension and a capability dimension. Processes are divided into 5 categories: customer-supplier, engineering, supporting, management and organization. Processes are also defined as to capability levels numbered from 1 to 3, where 1: describes an Initial level, 2: Management level and3: Improvement level.

The assessment process is part of the improvement. Assessment results provide the main input for the improvement action plan and provide feedback from the improvement activities implemented. During this model assessment the organizational processes are evaluated to define each process.

Process capability is measured based on the following capability levels:

Level 1 : Initial
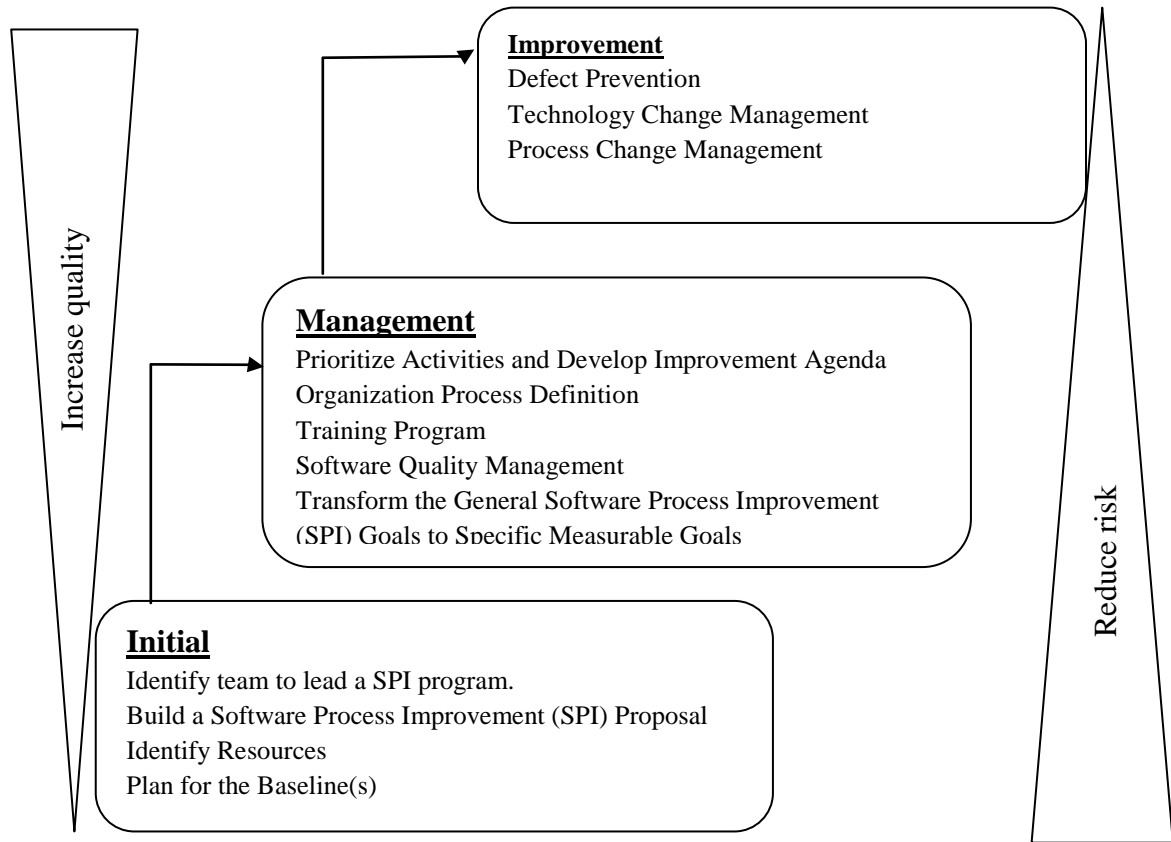
Level 2 : Management

Level 3 : Improvement

Figure3-1: levels of proposed model

3.2.3 Levels of the proposed model:

3.2.3.1 Level 1: Initial

The Initiating level of the model is the starting point. Here is where the initial improvement infrastructure is established, the roles and responsibilities for the infrastructure are initially defined, and initial resources are assigned. The general goals of the SPI program are defined during the Initiating level.

 Also during the Initiating level, plans are made for communicating the start of the SPI initiative, and it is suggested that organizational assessments be performed to determine the readiness of the organization for a SPI initiative.

3.2.3.2 Level 2: Management

During this level, the issues that the organization has decided to address with its improvement activities are prioritized, strategies for pursuing the solutions are also developed. The SPI action plan draft will be completed in accordance with the organization's vision, strategic business plan, lessons learned from past improvement efforts, key business issues facing the organization and long-range goals.

During this level, measurable goals are developed from the general goals that were defined in the Initiating level, these measurable goals will be included in the final version of the SPI action plan.

3.2.3.3 Level 3: Improvement

The objective of the Final level is to make this model more effective. By this time, solutions have been developed, lessons have been learned, and metrics on performance and goal achievement have been collected.

Using the collected information, an evaluation of the strategy, methods and infrastructure used in the SPI program can be performed. By doing this, corrections or adjustments to the strategy, methods, or infrastructure can be made prior to the start.

Some questions that should be asked include:

Has the infrastructure performance been appropriate?
Have the methods employed in their solution development activities been satisfactory?
Have the SPI communications activities been sufficient?
Does another baselining activity need to be performed?

The reentry point into this model for the next cycle is highly dependent on the answers to questions such as these.

Table 3-13: Activities done in each level

Level	Key Process Areas
Improvement	□ Defect Prevention □ Technology Change Management □ Process Change Management
Management	□ Select and Get Training in a Strategic Planning □ Prioritize Activities and Develop Improvement Agenda □ Reconcile the Existing/Planned Improvement Efforts with the Baseline(Findings and Recommendations) □ Organization Process Definition □ Training Program □ Transform the General Software Process Improvement (SPI) Goals to Specific Measurable Goals □ Software Product Engineering □ Intergroup Coordination □ Peer Reviews □ Software Quality Management □ Software Quality Assurance
Initial	□ Identify team to lead a SPI program. □ Identify Business Needs and Drivers for Improvement □ Build a Software Process Improvement (SPI) Proposal □ Identify Resources □ Define the Guiding Principles of the SPI Program and SPI Goals □ Educate and Build Support □ Plan for the Baseline(s)

3.2.4 Documentations in the proposed model

There are three different documents, which can be used in process assessment. These are: introductory documentation, process management and rating process .This documentations will be described blew:

3.2.4.1 Introductory Documentation

The purpose of the first document is to provide overall information of software process assessment and its use in two contexts, process improvement and process capability determination.

Basically a process is examined with an assessment, which leads to process capability determination and process improvement. Capability determination identifies the capability and risks of a process, and process improvement identifies the changes, which should be made to the process. Software capability determination generally motivates an organization to do process improvement.

3.2.4.2 Process management

This document defines various processes which can be used in various phases of production, named acquire, supply, development, support, evolve, and operate Processes, categorized into five process categories in A proposal model, are described below:

☐ **Customer-Supplier** - processes that directly impact the customer, support development and transition of the software to the customer, and provide for its correct operation and use

☐ **Engineering** - processes that directly specify, implement, or maintain a system and software product and its user documentation

☐ **Project** - processes which establish the project, and co-ordinate and manage its resources to produce a product or provide a service which satisfies the customer

☐ **Support** - processes which enable and support the performance of the other processes on a project

☐ **Organization** - processes which establish the business goals of the organization and develop process, product, and resource assets which will help the organization achieve its business goals.

3.2.4.3 Rating process

Document 3 is used in defining the minimum set of requirements for conducting a software process assessment. These requirements are used to ensure that the outputs of the assessment are consistent, repeatable and representative of the process instances assessed

A process assessment is practically done by assessing selected processes against the process A proposal model. The output of the assessment provides a set of capability level ratings for each process instance assessed.

Document 3 acts as a guide on using process assessment to understand the current state of processes, and to create and prioritise the improvement plans.

3.2.5 Qualification and training of assessor

A proposal model assumes that the assessment team includes at least one qualified assessor. This qualified assessor is in primary responsibility of the assessment, ensuring that the requirements are met during the assessment.

The result of the assessment obviously depends on the skilled judgement of the assessors. The achievement of an acceptable level of consistency, repeatability and reliability of results relies on competent assessors with appropriate skills, experience, and knowledge of the software process.

A qualified assessor usually acts as a team leader for the assessment team. This person is in responsibility of ensuring that other team members have the right blend of specialized knowledge and assessment skills. This qualified assessor has to provide the necessary guidance and lead to the team, and help to moderate the judgements and ratings made by other team members to ensure the consistency of the results.

3.2.6 The adaptation principles

1. Simple and easy to learn.

2. This model focuses on evolution aspects rather than evaluation ones. In fact, small enterprise would probably get low quality level, for example. Though, they need to know their strengths and weakness and they particularly need guidelines to improve their process.

3. The model uses a simplified vocabulary and easy to use of technical terminology.

4. Explicit relationship between the outcomes of processes and practices on the one hand, and the declared goals of the organization on the other hand, would be motivating in the improvement process.

Chapter Four: Results & Discussions

Chapter Four: Results & Discussions

The Companies are classified to be of small size compared with international Companies and this will accordingly affect both of the quantity and quality of software products. The proposed model designed to improve process software in small enterprise.

4. Results

The results that showed at the first glance the three companies at capability maturity less than improvement (value of mean at level3-improvement for three companies less than"central" value of Likert Scale). That means there are do not follow any software process improvement standards.

The results that showed both company (B,C) were not fully implemented level-2 and level-3 activities, at the proposed model level-1 (Initial).

The results that showed Company (A) all activities for three levels were not implemented needed to implementation the proposed model from begin (level-1).

Chapter Five: Conclusion& Recommendations

Chapter Five: Conclusion & Recommendations

5.1 Conclusion

Small software enterprises represent a high proportion of software companies around the world. However, these Small software enterprises do not have the suitable software process model to achieve all key process areas of one of SPI traditional models since these models are created to help large and very large companies.

Small software enterprises in Sudan need to have suitable software process models that can achieve all the activities of a selected SPI traditional model.

This research discussed this problem and how it can be solved depending on the characteristics of small software enterprises, as well as and getting the features required by small enterprises on SPI model. The proposed model was developed based on these requirements and general characteristics of software development companies in Sudan. A questionnaire was used to collect information from three case studies, the data was analyzed using SPSS tool to assessment capability of each company .based on the results the proposed model should be used in order to improve the quality in the three companies.

5.2 Recommendations

1- Software Development Companies in Sudan should work seriously to increase the company's size as well as financial ability and the number of the staff involved in the development process, in order to improve and enhance the general characteristics of these companies, and to cope with international Companies which will affect best practice adoption and the quality of Software Development products.

2- Software Development Companies in Sudan need to be acquainted with differentiated knowledge about best practice adoption through various co-operative strategies with international Companies and institutions in order to cope with the rapid improvement in the field of Software Development.

3- The proposed model could be applicable in case companies are having trouble in initiating SPI or have concerns about the cost of implementing SPI.

4- Management commitment and support is important critical factor to success improvement.

References

1- A.Raninen (2014):Practical Process Improvement:" How to Initiate Software Process Improvement in a Small Company".

2- ESSI, IBERIA, LAE. February. (1994): SPIE: Software Process Improvement and Experimentation ESSI Project: No 10344.

3- D.Vernon : Software Engineering 2 , Khalifa University Module 514.

4- R. S. Pressman: Software Engineering Apractitioner's Approach Seventh Edition.

5- D.L. Johnson and J.G. Brodman, 1999 :"Tailoring the CMM for Small Businesses, Small Organizations, and Small Projects," Elements of Software Process Assessment and, K. El Emam and N.H. Madhavji, eds., Improvement IEEE CS Press, , pp. 239–259

6- C.Kaner, and W. P. Bond(2004): Software Engineering Metrics: What Do They Measure and How Do We Know?.

7- C. J. Alberts, J. H. Allen, R. W. Stoddard (September2010): Integrated Measurement and Analysis Framework for Software Security.

8- I. Richardson, (2007): Guest editors Introduction Why Are Small Software Organizations Different?

9- K.Kushnir, 2004:"How Do Economices Define Micro, Small and Medium Enterprises (MSMEs)?".

10- S. Alexander, A. Renault,(2008) :"The Application of International Software Engineering Standards in Very Small Enterprises,".

11- K.E. Wiegers (May 1996):" Software Process Improvement", Ten Traps to Avoid1 .

12- M.C. Paulk, B. Curtis, M.B. Chrissis, and C.V. Weber (February 1993), "Capability Maturity Model for Software, Version 1.1" Software Engineering Institute, CMU/SEI-93-TR-24.

13- A. M. Elhag, M. A. Elshaikh, Radziah Mohamed, M. I.Babar,2013: Problems and Future Trends of Software Process Improvement in Some Sudanese Software Organizations , International Conference On Computing, Electrical And Electronic Engineering (ICCEEE),Sudan Burj Elfatih.

14- B.Linders,Senior Consultant 2010:Process improvement, The Agile Way!

15- M.Lepmets, Luxembourg and T.McBride,2012: Process Improvement for the Small and Agile , EroSuPI² Conference ,Australia.

16- N. Habra, S. Alexandre, J. Desharnais, C. Y .Laporte,A.Renault, (2008): Initiating software process improvement in very small enterprises. Information and Software Technology, 50, 7-8, 763-771.

17- A.Renault, N.Habra, E.Niyitugabira, S.Alexandre, J.Deprez, (2006): OWPL model: Software process improvement for VSE, SME and Low maturity Enterprises. Technical Report, CETIC_ FUNDP, Belgium. available at http://www.cetic.be/IMG/pdf/OWPL-Model_V1-2-2-EN-V22.pdf

18- D. Mishra, and A.Mishra ,2009: Software Process Improvement in SMEs: A Comparative View , Ankara, Turkey.

19- S.Alexandre, A. Renault, N. Habra, (2006) : OWPL: A Gradual Approach for Software Process Improvement in SMEs. Proceedings of the 32nd EUROMICRO Conference on Software Engineering and Advanced Applications.

20- M.M. Saeed ,(January 2014):General Characteristics of Software Development Companies in Sudan and its Impact on Production , International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 3, Issue 1.

21- K.E. Wiegers(May 1996):" Software Process Improvement", Ten Traps to Avoid1

22- F. J .Pino , M.Piattini (November2007), "Software process improvement in small and medium software enterprises : asystematic review".

23- The International Process Research Consortium (IPRC), Software Engineering Institute, Pittsburgh, (2006) : SEI – Software Engineering Institute "Improving Processes in Small Settings (IPSS) – A White Paper",. (http://www.sei.cmu.edu/iprc/ipss-white-paper-v1-1.pdf).

24- A. M. Solyman, O. A. Ibrahim, 2015: Project management and software quality control method for small and medium enterprise, International Conference On Computing, Electrical And Electronic Engineering (ICCEEE).

25- S.M. Hwang (January, 2009): "Process Quality Levels of ISO/IEC 15504, CMMI and K-model", International Journal of Software Engineering and Its Applications Vol. 3. , No. 1.