THE ADOPTION OF SOFTWARE PROCESS IMPROVEMENT (SPI) PROGRAM IN THE CONTRUCTION INDUSTRY

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ABSTRACT

Integrating the design process and automating the construction process are called for in the Industrialised Building System (IBS) Roadmap 2003-2010 and the Construction Industry Master Plan (CIMP) 2006-2015. Hence, the industry needs to improve the construction delivery process by having as many processes utilizing advanced IT/ICT technologies. With a goal of producing zero product failure and meeting the users' requirement satisfaction, this is an initial study into automating the construction tasks by studying a systematic process management commonly used for software implementation. We present a feasibility study on the use of a Software Process Improvement (SPI) Program in an IT organization—assuming that the construction organization will become an implementer of computer-integrated procedures in the future. Based on a case study conducted at a local IT software company, it documents the implementation of a SPI program to improve the internal software process development. The study uses the Capability Maturity Model Integration (CMMI) from Software Engineering Institute as SPI framework and IDEAL model-SPI life cycle model for executing and managing SPI program. Results show that the SPI Program model is successful in terms of the IT organization increasing its work productivity, high end-user product satisfaction and reduction of software defects. The paper concludes with discussions on how we can bridge computer science approach into the construction industry, thereby contributing to the development of future theoretical and application methodologies towards applying IT/ICT initiatives in the local construction industry.

Keywords: Software Process Improvement, Automation in Construction, Integrated Design Management

1. INTRODUCTION

Integrating the design process and automating the construction process are called for in the Industrialised Building System (IBS) Roadmap 2003-2010 and the Construction Industry Master Plan (CIMP) 2006-2015. Hence, the industry needs to improve the construction delivery process by having as many processes utilizing advanced IT/ICT technologies. With a goal of producing zero product failure and meeting the users' requirement satisfaction, this is an initial study into automating the construction tasks by studying a systematic process management commonly used for software development. In this paper, we present a feasibility study on the use of a Software Process Improvement (SPI) Program in an IT organization—expecting that the construction organization will become an implementer of computer-integrated procedures in the future. Our concern is the feasibility of SPI implementation in a discontinuous organization (Ibrahim, 2005) which places the construction organization as a very dynamic organization and operating in a very dynamic environment. Discontinuous members in the construction organization enter the project team when needed, and leave the team when their tasks are completed (ibid.). Based on a case study conducted at a local IT software company, it documents the implementation of a SPI program to improve the internal software process development.

Nowadays, SPI has become one of the dominant approaches to improve quality and productivity in software engineering (Aaen et al., 2001). Based on the total quality management (TQM) principles as taught by Shewhart, Juran, Deming and Humphrey, "The quality of a product is largely determined by the quality of the process that is used to develop and maintain it." The aims of SPI program in IT industry are to reduce development costs through improved developer productivity and to improve end user satisfaction with the resulting software by reducing software defects (McGibbon, 1999). Thus, for managers and developers to perceive a SPI as useful, they would likely expect to see gains in quality and productivity as a result of using the SPI. Moreover, the goal of process improvement should not be achieving a particular level; the goal should be better products and services, produced on time and within budget (Fantina, 2005). Since the introduction of the SPI, many software organizations have committed to the initiatives and many outstanding SPI stories have been reported (Gibson et al., 2006; Diaz & Sligo, 1997; Haley, 1996; Humprey et al., 1991).

Performance results are categorized and summarized by cost, schedule, productivity, quality, customer satisfaction, and return on investment (ROI). For example, Boeing Australia has achieved 33% decrease in the average cost to fix a defect, and reduced by half the amount of time required to turn around releases (Goldenson and Gibson, 2003). Likewise, Northrop Grumman IT shows the reduction in defects found from 6.6 per KLOC to 2.1 over 5 causal analysis cycles, earned a rating of "Exceptional" in every applicable category on their Contractor Performance Evaluation Survey and 13:1 ROI calculated as defects avoided per hour spent in training and defect prevention (Goldenson and Gibson, 2003).

The remainder of the paper is organized as follows. Section 2 reviews the SPI and empirical studies that have investigated the factors that influence the implementation of SPI initiatives. Section 3 describes the research method of our study which is a case study conducted at one IT organization in Malaysia. Section 4 presents our analysis and discussion. We conclude with recommendations on how we can adopt SPI for implementation in the construction industry.

2. LITERATURE REVIEW

This section introduces SPI, organization approach towards software process improvement adoption and the key success factors of successful implementation of SPI adoption.

2.1 Software Process Improvement (SPI)

SPI has been used over a decade in the software industry as a systematic approach to improve software organization capabilities. Szymanski and Neff (1996) defines SPI as a deliberate, planned methodology following standardized documentation practices to capture on paper (and in practise) the activities, methods, practices, and transformations that people use to develop and maintain software and the associated products".

SPI approach was introduced by Watts Humphrey (1989) through the Software Engineering Institute (SEI) at Carnegie Mellon University. SPI benefits that improve organizations capability have seen many organizations committed to this ardous journey and expensive exercise. This can be seen in the literature, case study and technical reports reporting the success stories of SPI. Zahran (1998) proposed software process improvement framework that comprises of four components which are software process infrastructure, software process improvement roadmap, software process assessment method and software process improvement plan. These four components are interrelated and absence of any components may lead to deficiency in the software process programme. Software process improvement is a cycle. Further, Aean et al. (2001) proposes three sets of ideas extending the SPI ideas for improving practices in software organization: the *management* of SPI activities, the *approach* to guide the SPI initiatives, and the *perspective* used to focus on the SPI goal. These ideas offer to create and manage improvement program based on SPI ideas.

Software Process Improvement Models. The first step in improving the capabilities of software organization is to understand the current status of the software development practices in the organization (Humphrey, 1989). The most common approach to evaluate the organization's status is via assessment using a model as a road map. There are many assessment approaches that an organization can use to identify what should be improved. The most popular assessment model is Capability Maturity Model Integration (CMMI) from SEI (Chrissis *et al.,* 2003). Other approaches include CMM (Paulk et al., 1993), SPICE (El Emam et al., 1998a), Bootstrap (Kuvaja et al., 1994) and QIP (McGarry et al., 1994). Although there are multiple existing approaches, common to all these approaches is that they apply Total Quality Management principles to SPI. Therefore, the models not only present a practical roadmap for improving organization's processes, but it also specifies a method for appraising current processes for identifying their strengths and weaknesses, and proposing recommendations for process improvements (Zahran, 1998).

Capability Maturity Model Integration (CMMI). SEI (2002) claimed that CMMI consists of best practices for the development and maintenance of both product and services. CMMI plays an important role in continuous process improvement especially to conduct organization assessment because it is the reference against which development process strengths and weakness are diagnosed. The purpose of CMMI is to provide guidance for improving an organization's processes and ability to manage the development, acquisition, and maintenance of a product or services. This model covers four disciplines: software engineering (SW), system engineering (SE), integrated product and process development (IPPD) and supplier sourcing (SS). The CMMI model supports two views of the CMMI, a process capability view (continuous representation) and an organizational maturity view (staged representation). Continuous representation uses capability levels to measure a process capability as a basis for improving the specific process; while the staged presentation uses maturity levels to measure the process capability of an organization as a basis for improving the organization's process capability (Zahran, 1998). CMMI has placed proven approaches into a structure that helps an organization to appraise its organizational maturity or process area capability, establish priorities for improvement, and implement these improvements (SEI, 2002). CMMI continuous representation uses capability levels to measure a process capability as a basis for improving the specific process. A capability level consists of related specific and generic practices for a process area that can improve the organization's processes associated with the selected process area (SEI, 2002). A process area is a cluster of related practices in an area that, when performed collectively, satisfy a set of goals considered important for making significant improvement in that area (SEI, 2002). In order to reap the benefits of process improvement by achieving targeted capability level, organization needs to satisfy generic and specific goals for a process area at a particular capability level. This capability levels achievement will enable the organization's ability to perform, control and improve its performance in a process area. The measurement of capability level achievement will be evaluated with an assessment. However, CMMI framework does not provide data on how to implement SPI initiative. Towards the end, we propose the use of the IDEAL model (McFeeley, 1996) to organize and manage our SPI initiative.

IDEAL Model. The second part of SPI is the implementation phase. Researches have shown the use of SPI model and standard such as Software Process Improvement and Capability Determination (SPICE), Capability Maturity Model (CMM) and most recently Capability Maturity Model Integration (CMMI) that can produce high quality software, increasing productivity and reducing cost and time. However, Goldenson and Herbsleb (1995) study shows that little attention was paid to implement these models and standard effectively. Their study shows that 67% of the SPI managers want guidance on how to implement SPI activities, rather than having to list SPI activities for actual implementation (Herbsleb and Goldenson, 1996). Therefore, to support the implementation of software process improvement, the SEI proposes a framework called IDEAL Model. The IDEAL model is a life-cycle approach that can be used for SPI managers to manage and drive the SPI initiatives in organization (McFeeley, 1996).

IDEAL Model consists of five phases which provide structures for continuous improvement (Gremba and Myers, 1997). Specifically, the model derives its name –IDEAL- from the first letters of these phases. As shown in Figure 1, five main phases are **I**nitiating, **D**iagnosing, **E**stablishing, **A**cting and **L**earning. These five phases consist of 14 activities. The length of time taken to complete the cycle of IDEAL model varies from organization to organization depending on the resources (McFeeley, 1996). Below are the purposes of each phase:

(1) The *Initiating phase* (laying the groundwork for a successful improvement effort).
(2) Diagnosing Phase (SPI action plans are initiated according to SPI vision and goals, baseline organization current state).
(3) Establishing Phase (prioritization of SPI areas, establish tactical action team).
(4) Acting Phase (solutions to the prioritised SPI areas are created, piloted and deployed, plans for full deployment are developed and executed).
(5) Learning Phase (lesson learned are made, collected data is analysed, conclusions for improvements of SPI work is made).

The IDEAL Model aims to establish continuous improvement. Indeed, the main strength of this model comes from the fact that it has been derived from actual industry cases, rather than being a theoretical or untested model (Kinnula, 2001).

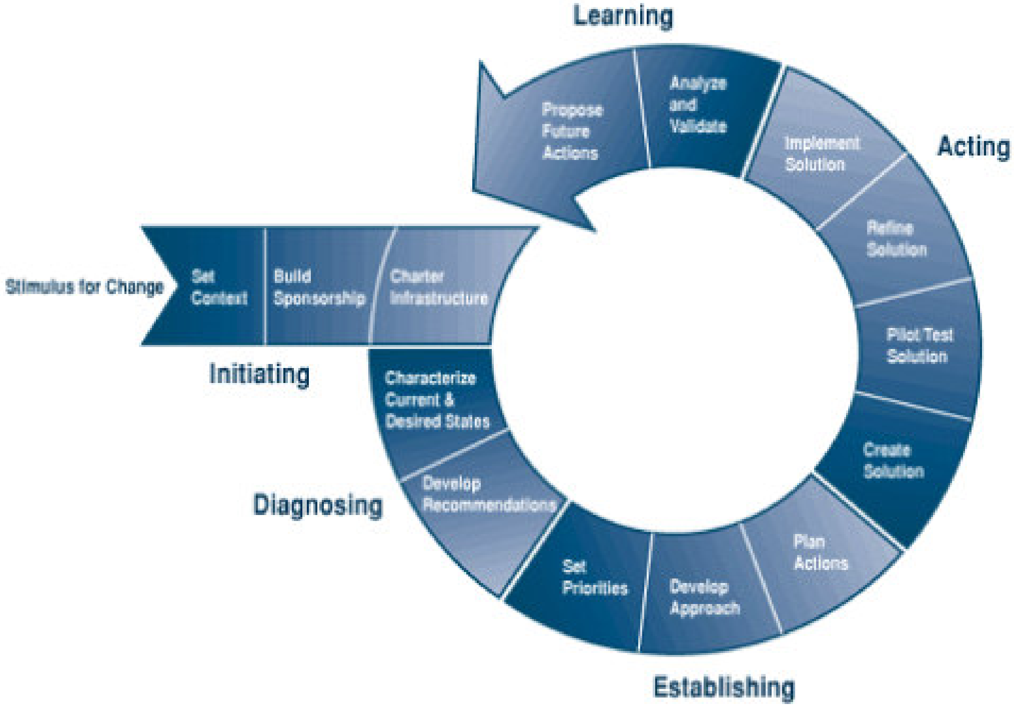

Figure 1: The IDEAL model.
(Source: Adopted from Gremba and Myers (1997). Available on http://www.sei.cmu.edu/ideal/ideal.bridge.html)

2.2 Critical Success Factors of SPI

Numerous studies have explored key factors of SPI (Rainer and Hall, 2002 & 2003; Dyba, 2000 & 2005; Jalote, 2002; Stelzer and Mellis, 1999). Successful SPI depends on many interrelated factors during different stages of SPI implementation. Goldenson and Herbsleb (1995) conducted a survey of 138 individuals from 56 software organization in United States and Canada to evaluate the organizational factors that may become barriers for successful process improvement. The organizational factors for successful SPI are: (1) Senior management monitoring of SPI, (2) Compensated SPI responsibilities, (3) Involvement of technical staff in SPI, (4) SPI people well respected, (5) SPI goals well understood and (6) Dedication of staff time and resource to SPI. In addition to the organizational factors, barriers that may inhibit the SPI successfulness are: (1) Excessive organizational politics, (2) "Turf guarding" inhibiting SPI, (3) SPI gets in the way of "real work", (4) Discouragement of SPI prospects, (5) Ambitious appraisals' recommendations were too ambitious and (6) Need for more guidance, mentoring and assistance in implementing SPI.

Furthermore, El Emam et al. (1998b) reanalyze the Goldenson and Herbsleb (1995) study using the multivariate analysis instead of simple statistical analytical methods used in the initial study. Based on the reanalysis, they identified two classes of independent variables that influence the SPI success: organizational factors and process factors. They also identified commitment to SPI, politics, turnover, respect and focused SPI effort as the dimension of the organizational factors.

Stelzer and Mellis (1998) analyzed published experience reports and case studies of 56 software organizations that had implemented ISO 9000 quality system or that had conducted a CMM-based process improvement initiative. The result of the analysis were 10 factors affecting organizational change in SPI. These factors were: (1) Management commitment and support, (2) staff involvement, (3) providing enhanced understanding, (4) tailoring improvement initiatives, (5) managing the improvement project, (6) change agents and opinion leaders, (7) stabilizing changed processes, (8) encouraging communication and collaboration, (9) setting relevant and realistic objectives, and (10) unfreezing the organization.

Rainer and Hall (2002) have identified eight factors that have major impacts on the implementation of SPI. Generally from practitioners' point of view, four factors—reviews, standards and procedures, training and mentoring, and experienced staff—have major impacts on implementing SPI. Additionally, four additional factors must also be considered for mature companies to implement SPI, i.e., internal leadership, inspections, executive support and internal process ownership.

Dyba (2005) extends and integrates model from prior research (Dyba, 2000) by performing an empirical investigation of the key factors for success in SPI. The proposed model comprises of six independent variables: business orientation, involved leadership, employee participation, concern for measurement, exploitation of existing knowledge and exploration of new knowledge. This quantitative survey of 120 software organizations shows the insignificant importance of involved leadership in predicting SPI success.

In order to implement SPI program, different organization will adopt different approaches. To ensure the successful implementation of any SPI effort, a practitioner or an organization that wishes to implement process improvement initiatives needs a deep understanding on the above factors that can affect the success and failure of these improvement activities. This model is used as a framework to implement SPI program in our study which is presented in the next section.

3. CASE STUDY RESEARCH METHODOLOGY

We use a case study research methodology to study the emerging issues that influence the SPI implementation in an IT organization context. Then, with that knowledge we could extend the SPI implementation in a construction operating environment. Figure 2 shows the research methodology flows. Our research question is: What are the key components to apply SPI in an IT organization? The Unit of analysis is a Malaysian Company involved in providing IT services with staff numbering 300 people with various IT background (hereafter named Company ABC for confidentiality).

The project is conducted in a small setting, which is at one department of Company ABC that has a SPI goal to improve the most critical area in business needs due to resource constraint. The department has 50 staff and data were collected on site for a period of 5 months from April to September 2005. Data collection involved action research (Baskerville and Wood-Harper, 1999) where the first author performed the role of a Technical Executive for the Software Engineering Process Group (SEPG), and Assessor to the Technical Work Group (TWG) in the process improvement effort. Specifically, the first author is fully involved in initiating, diagnosing and establishing phases, and a part of acting phase. For the purpose of reporting the organizational behavior during the tacit-dominant phases of the SPI process, we limit this paper to reporting three phases (*Initiating*, *Diagnosing*, and *Establishing*). *Tacit knowledge* is the entity of "knowing how" that an individual or an enterprise possesses in selecting and applying a group of facts, which enables action to complete a task (Polanyi, 1967; Nonaka, 1994).

Based on SPI literature (Fuggeta and Pico, 1994; Paulk, 1999), experiences of various organizations which had implemented SPI worldwide (Gibson et al., 2006; Diaz and Sligo, 1997; Haley, 1996; Humprey et al., 1991), and after analyzing the collected data, Company ABC decided to use the CMMI model as the SPI model which focused on improvement effort on the weakest process area defined by organization's business objectives and priorities. In Company ABC, its small size, costly services, and time constraint qualify it to adopt CMMI (Staples et al., 2007). However, it is not subjected to another SPI model being implemented concurrently. CMMI model allows for flexibility because it provides two views—*stages representation* and *continuous representation.* In Company ABC context, managing all requirements is the most critical need for improvement so that the company can produce better software that meet user requirement. With the flexibility of continuous model chosen, Requirement Management (REQM) and Requirement Development (RD) process areas are chosen for the initial process improvement initiative.

For organising, planning and carrying out SPI efforts, Company ABC chooses to adopt IDEAL model because it can guide SPI initiative (McFeeley, 1996), practical application with tailoring (Casey and Richardson, 2004, Kautz et al., 2000) that suits Company ABC's practices. The use of both CMMI and IDEAL models is to ensure the effectiveness of continouous improvement. On one hand, the CMMI model becomes the SPI foundation because it is based on the industry best practices. Its assessment provides the guideline on areas that need to be improved. On the other hand, the IDEAL model guides the implementation of process improvement initiative to be more manageable and systematic. Furthermore, both these model give flexibility to do tailoring based on organization needs (McFeeley, 1996). Tailoring means the company needs to adjust the project activities to reflect the uniqueness of the project while keeping the project's goal in mind. In this project, we tailor the IDEAL models in term of the duration it takes to complete the full cycle of the model, activities of each phase, resources, work product, SPI infrastructure and SPI goals. Therefore, tailoring is the best guide to the study's situation to ensure that the SPI initiative achieves its objectives in time and within budget.

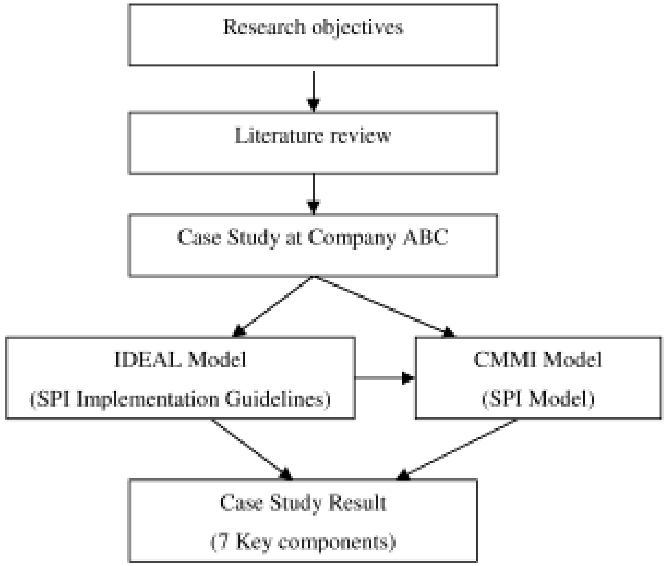

Figure 2: The Research design.

4. RESULTS OF PROCESS IMPROVEMENTS USING IDEAL MODEL

In this section, we report Company ABC's experience in implementing process improvement using IDEAL model and describe the three sequential IDEAL phase - Initiation, Diagnosing, Establishing. We also described the one concurrent learning phase for these three phases.

Initiating Phase. Initiating phase is the starting point of a SPI program (McFeeley, 1996). As the SPI program was implemented like any ordinary software development project, thus, the project organization was designed so that the team members were aware of their roles and responsibilities. The organization consisted of Management Steering Group (MSG) that included four software managers responsible to guide the SPI implementation activities and to allocate resources to the project, and Software Engineering Process Group (SEPG) (consisting of seven project managers and developers) who were responsible to facilitate SPI improvement activities including maintaining the motivation and the enthusiasm for process improvement within the organization. The first meeting was to determine the business reason for change and align the reason with business goal. SPI proposal and project plan for the initiative were prepared in consultation with the MSG and SEPG. The SPI Proposal and Plan formally recognized the current and desired states for process improvement in organization. It set priorities for change and it formally outlined the business reasons for the initiative. It laid out the time frame and highlighted key activities that would have to be carried out to implement the tailored process in keeping with the IDEAL model.

Diagnosing Phase. This phase is the basis for the process improvement and to know the organization process capability. "*If you don't know where you are, a map won't help*" (Humphrey, 1989). The CMMI-based approach was chosen to perform the assessment to identify organization strengths and weaknesses, and propose recommendations for process improvements. As a preparation for assessment, information about CMMI and what was involved in CMMI assessment was distributed to the team whose project was being assessed. One official meeting was held to roll-out the assessment initiative. Three types of assessment instruments included interview questions, checklists and Practice Implementation Indicator Description (PIID) template. Besides these instruments, the assessment procedure also applied two other methods to gather supportive evidence, namely documentation and presentation. For the assessment, three projects were selected. Two process areas, Requirement Management (REQM) and Requirement Development (RD) were chosen to be assessed. From the assessment, both REQM and RD were in capability level 1: Performed. A "performed" process is a process that satisfies the specific goals of the process area and it supports and enables the work needed to produce work products. The findings were presented to management and the project teams to ensure they were aware of what had been achieved. Lastly, the final report was prepared to document the assessment findings, describe the key findings, and make specific recommendations to the project based on the findings.

Establishing Phase. The purpose of this phase is to develop SPI strategic plan that will provide guidance and direction to the SPI program. After completing diagnosing phase, the MSG reviewed the assessment report and prioritized the establishment of a strategic action plan. The action plan was prepared which outlined the schedule, roles and milestones for the initiative. The SEPG met and undertook the implementation of the action plan. The SEPG members also took responsibility for informing management and staff, on a regular basis, on the status of the initiative. The next step was the selection of the Technical Work Group (TWG). The responsibilities of TWG was to address the requirement of REQM and RD process areas to ensure the appropriate processes, templates and standards were generated using the CMMI framework as a guide. Feedback on the progress of the initiative would be presented to the rest of the teams on a regular basis through the SEPG.

Learning Phase. A distinct data collection on learning phase as in the IDEAL model did not take place during the twenty-week period. Instead, this documentation of learning was collected during the first 3 phases reported above. From this SPI program exercise, Company ABC has introduced requirement management system based on the REQM and RD process area for its internal use. With this system, monitoring of the performance for requirement management in software development project will be evaluated and reviewed. Better software is expected to be produced with a specification that meets user requirement of being within budget and time. The MSG, SEPG and TWG had shown their effort and support while the sponsor had been committed to the intiative. Throughout the study, all materials and experience gained were documented and stored. This valuable resource is retained in online repository where it is to be utilized in future process improvement activities.

In summary, the implementation of the SPI using IDEAL model has to go through five phases that is initiating, diagnosing, establishing, acting and learning. However, we only report Company ABC's experience in implementing process improvement for the first three phases which are initiating, diagnosing and establishing. We also report the learning phase during these phases.

In the implementation of SPI using IDEAL model through first three phases, we have identified the seven key components as the critical success factors for implementing SPI. Identification of these components is based on the result of learning phase that occurs during the three phases of the implementation cycle. We summarize the seven key components that we have identified in this learning phase in the following Section 5.

5. DISCUSSION AND ANALYSIS

From the three phases of IDEAL Model (Initiating, Diagnosing and Establishing), we have identified seven key components as the critical success factors of implementing SPI program. These key components were identified as a result of lesson learned when conducting the first three sequential phases. Beside the results from the case study, we refer to relevant literature to support the explanation of our observations in the SPI process. The key component discussed in this section is factors that need attention from organization when they start implementing SPI initiative. For each key component, the study is determined whether or not this key component is relevant to be implemented in construction industry.

Top Management Commitment and Support. In many of software process improvement literature (Dyba, 2005; Jalote, 2002; Diaz and Sligo, 1997; El Emam et al., 1998; Stelzer and Mellis, 1998; Goldenson and Herbsleb, 1995), it is well established that management commitment is vital to the successful implementation of process improvement initiative. Top management is the person that holds the highest position in the organization and has the authority to make a decision. The commitment and support of top management is essential in providing the resources (funding and people), monitoring of the SPI progress, prioritizing the SPI and resolving SPI issues. In any SPI initiatives, the changes in an organization's culture and resistance of staff members to adapt to the new changes are always difficult without the top management support. Moreover, Humphrey (1989) argues that major changes to the software process must start at the top and ultimately, everyone must be involved in the process change. The role of top management to participate actively in SPI can be the strong motivator to people that participate in SPI. Furthermore, Diaz and Sligo (1997) proved that senior management sponsorship was critical to the success of the process improvement efforts. This sponsorship is not only taking an active interest in the progress of various process improvement initiatives, but also providing funding and time to do the work, and rewarding those who contributed.

In the construction industry, the top management has the bird's eye view of the overall development process and progress of a building project. Given the discontinuity of the project team (Ibrahim, 2005), members of the construction team have a high likelihood of questioning the motive for any process change when their respective contributions only involved in one phase of the development process.

Process Improvement Infrastructure. Process improvement infrastructure is vital to provide guidance for the SPI program. Formation of process improvement infrastructure such as Meeting Steering Group (MSG), Software Engineering Process Group (SEPG) and Technical Work Group (TWG) in SPI program provides practical ideas for improvement (McFeeley, 1996; Dion, 1999; Weigers ,1996). Thus, these groups must be staffed with highly respected people in the organization who have clear responsibility for SPI and really give full commitment to the SPI activity (Hersbleb and Goldenson, 1996). Likewise, the technical staff must be involved in the effort because the right people to define process are the practitioners who are the members of the process improvement team, not the outside process experts (Diaz and Sligo, 1997). Moreover, Beitler (2003) argues the need to create a transition management team to provide emotional support and practical ideas for the organizational change. Building the right team is important to ensure enough resources to sustain the SPI program. In this matter, the best investor is the building developer, and not the contractor or the consultants. If the developer would provide the right economic incentive to the appointed members of a project team, we believe that the other team members would be glad to install the required additional infrastructure. More studies would be needed to balance the additional investment for process improvement infrastructure as opposed to the outcome revenue gain in the future of the development organizations.

Staff Participation. Staff participation and teamwork has been one of the most important foundations of organization development and change. Participation of internal staff in SPI project makes the management of the SPI project easier because they are well respected in their own organization (Goldenson and Herbsleb, 1995) compared to outside experts. Furthermore, the staff are the best people to participate in SPI because they have the detailed knowledge of the process especially the weaknesses of the process that they want to solve. However, some staff do not understand how this process improvement can support their daily work (Stelzer and Mellis, 1998). This may due to lack of SPI understanding or resistance towards SPI program that change the way they work. In this case, the role of management in giving support, acquiring SPI knowledge and providing SPI awareness program may contribute to the better understanding of SPI among staff. Unlike a stable organization, a building project team consists of several team members who are mostly appointed to perform their services at selected different phases of a project lifecycle. Due to this factor, the vision and strength of the top management's leadership become more crucial for any process change improvements to occur. More studies are proposed to understand how a discontinuous organization could provide incentives to its team members.

Learning and training. Software process improvement can only be successfully implemented if members' of the organization have thorough understanding and knowledge of SPI activities. Most successful stories of SPI initiative come from organizations who do not neglect the need of learning and training among their staff members. Moreover, effective change is built on knowledge (Humphrey, 1989). There are many ways to acquire knowledge of SPI. The most common approach is through training. Lack of training and failure to understand the whole SPI program can be a trap that leads to unsuccessful SPI effort (Weiger, 1996). Although many organizations use consultants to help during the SPI implementation, it is important that the knowledge can be transferred (Somers and Nelson, 2001) to the internal employees. In doing so, the organization with skilful employees can implement their SPI programs without outside assistance. Hence, the organization should provide opportunities to its employees to enhance their skills by providing continuous basic training especially on software process improvement needs to tackle the future changing needs of the business. We support the recommendation for additional training to members of a project team including understanding the roles and responsibilities of different team members.

Managing the SPI Project. Good management of SPI project means the project is effectively planned and controlled (Stelzer and Mellis, 1998). SPI implementation without proper planning and project management leads to *ad hoc* decision and sometimes chaotic practices. Often, SPI project have no specified requirements, project plan or schedule (Stelzer and Mellis, 1998). In literature, some authors proposed the SPI to be managed as a project like an ordinary software development project (Jalote, 2002; Stelzer and Mellis, 1998). Standard project management requires analyzed requirements, clear and realistic goals, committed resources, defined responsibilities, established milestones and agreed budget. Additionally, we recommend future studies on how the above standard project management requirements could support the discontinuity in organizations (Ibrahim, 2005) in development project teams. Any SPI project that begins with clear goals and objectives (Herbsleb and Goldenson, 1996; Somers and Nelson, 2001) may get management support because management knows the direction and the benefits of the project outcome in the long run. For an organization having limited resources, SPI project would be the best approach to start the SPI initiative. Despite the fact that a SPI project is well documented, we are concern on how we could capture both tacit and explicit knowledge throughout a development project's lifecycle so that the successfulness of SPI at one local or site level can be extended to the entire organization. Hence, further studies are recommended to fit the SPI approach in a construction organization.

SPI Awareness. The benefits of SPI should be promoted to the staff members of the organization before the software process improvement implementation takes place in the organization. Likewise, if any change process is to take place in the construction industry. Niazi *et al.* (2005) identified SPI awareness as a new emerged success factors which were not identified in literature previously. They argue SPI awareness is a very important factor to get support from management and practitioners in order to sustain successful SPI initiatives. Unrealistic expectations of SPI among staff require the organization to manage those expectations if it wishes to maintain long term support for continuous process improvement (Goldenson and Herbsleb, 1995). Indeed, awareness program should be in place to promote the long-term benefits of SPI and should be an integral part of an SPI Implementation. Awareness is vital to the staff so that they understand that process improvement is not apart of their job. It should integrate with their daily work (Stelzer and Mellis, 1998). The same applies to managers at all level. They should not treat process improvement project and software development project as different projects. Process improvement should be applied in the software development project, and similarly in a construction development project. Otherwise, the staff will be burden with two jobs instead of integration of both jobs.

SPI Methodology. SPI model presents a well-defined roadmap for process improvement. It has shown to provide a methodology to appraise organization processes for identifying their strengths and weaknesses, and proposing recommendation for process improvements (Zahran, 1998). Despite having the capability to identify which process improvement ought to be deal with first, there is little attention being paid to the effective implementation of SPI initiative (Goldenson and Herbsleb, 1995). Their study shows that 67% of the SPI managers would like guidance on how to implement SPI activities, rather than what actual SPI activities to be implemented. Not only for the software industry, the authors believe that future studies are recommended in developing practical implementation methodology for the construction industry.

6. CONCLUSION

In this paper we describe our findings from the first three sequential phases of the IDEAL model and the concurrent learning phase during those phases in view of potential SPI implementation for the construction industry. Our study summarised seven key components that the learning phase found which we later determined whether it is relevant in the construction industry. Similar to SPI implementation in a software development organisation, the study fully supports the top management commitment and support, learning and training, and process improvement awareness as the important key components in adopting the SPI program for the industry. Unlike a software development organisation whose staff participation and process improvement infrastructure are vital to ensure the success of SPI program, the best investor in computer-integrated processes in the construction industry is the property developer. Future studies are recommended on how the industry can further develop a process improvement infrastructure. With discontinuity (Ibrahim and Paulson, 2008) being an inherent character to construction organisations, top management's leadership become more crucial for any process change improvements to occur. More studies are recommended in leadership and management of discontinuous organisations pertaining to such change improvements, and the development of practical implementation methodology for construction industry. This study highlights one potential methodology to automate a building process or implement IT-integrated processes in a building project or building organisation.

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