Software Engineering Practices in Jordan

Nuha El-Khalili
Faculty of Information Technology, University of Petra, Amman, Jordan
nuhak@uop.edu.jo

Dima Damen
Faculty of Information Technology, University of Petra, Amman, Jordan
dimad@uop.edu.jo

ABSTRACT

Existing software engineering literature acknowledges that the existence of fundamental software engineering practices would improve the success rate of IT projects. These practices range from having clear organizational standards for performing software development activities, utilizing CASE tools, all the way to project management practices. The purpose of this research is to measure the degree of applying these software engineering practices in ITC companies in Jordan, in order to identify areas of improvement to increase the competitiveness of these companies within the IT market.

Keywords: software engineering, process evaluation, product quality, CASE tools, empirical study

1. Introduction

The establishment of the National Information Center (NIC) in Jordan in 1993 was the first practical step towards indulging Jordan in the current information age. Since that time, NIC has been responsible for setting Jordan's information policies and strategies. The latest document published by the NIC, titled "Information Age, Policies and Strategies: An update of Jordan's National Information Policies and Strategies (2001-2004)" mentions the policy framework, which states two important strategy elements that should be implemented in the coming period. These strategies are:

1. "Active businesses in the information and information technology sector need to contribute more to the national economy. They need to enhance their competitive position. They also should become stronger and improve their management, quality control and marketing"
2. "IT education has to be enhanced to increase the quantity and quality of human resources…. Professional institutes should support the establishment and maintenance of standards". [1]

The information sector includes a number of various activities ranging from communication facilitation activities, hardware facilitation and maintenance, to software development activities. In this research we are interested in investigating the quality of the software development activities in Jordan in order to achieve the following goals:

1. Identify strengths and weaknesses in the software development process to improve it.
2. Improve the quality of the products and services provided by software development companies.
3. Identify weakness areas that require specialized skills and knowledge in order to focus on them during the education and training of IT people.

Section two of this paper reviews other empirical studies done to measure the implementation of some aspects of software engineering in different countries. Section three lists a number of software engineering practices that we considered vital for IT software development companies. This study's questionnaire was designed based on this list. Section four

presents details about the empirical method used to collect data, and section 5 illustrates significant results found in this research. Finally, the paper concludes with a set of recommendations reflecting the research results.

2. Literature Review

There is an agreement between academics working in the software engineering area on the need for more empirical research that measures the effectiveness of software engineering theories, methods, and tools and identifies and solves real life problems rather than theoretically assumed ones [2]. Empirical studies in software engineering either use case studies, surveys, or pilot studies.

The majority of these studies were conducted to identify the success factors that affect the software development process (space will only allow mentioning some examples rather than providing an exhaustive literature review). Some studies focused on specific types of industries, such as a study on the critical success factors of the information centers in the Hong Kong banking industry [3]. That study also compares the different perspectives of the managers and end users reflecting the importance of each success factor.

Another example of a focused study is presented in [4] where success factors were investigated for organizations that undertook the capability maturity model (CMM). The survey aimed at identifying factors that contribute to the successful adoption of CMM and measuring the impact of utilizing this model on improving the organization. The study showed that "managers actively monitor(ing) the progress of the adoption of CMM" formulates a major success factors in organizations.

Both [5] and [6] mention that success indicators of IT projects are: meeting time schedules and budgets and customer satisfaction, which can be indicated by a number of software qualities such as maintainability, testability and validity. Both studies also noted a number of factors that influence the success of IT projects. Among these are: process and requirement stability, project management, team member collaboration and flow of information between them, coordination with stakeholders, experience and training of team members, and finally techniques and tools used during the development process.

In [7] Limayem and Khalifa investigated factors that affect the utilization of CASE tools in 290 software development organizations. Results showed that among the proposed factors only two significantly affected the usage of CASE tools, which are: facilitating conditions (these are factors in the organization environment that assist in CASE utilization such as management support, available expertise, organization norms and standards) and habits. A third factor that was identified to be of some significance is the "perceived effect of the CASE tools on maintenance of software".

In [8], Dyba studied the differences between large and small Norwegian IT companies in implementing strategies of the software process improvement program. Results show that quality management approaches should differ based on the organization size. For instance large organizations depend on their guidelines, rules, procedures and models to improve their processes, while small organizations utilize the creativity of their personnel and their structural flexibility to improve their processes. However, the study shows that the success factors of small and large organizations are similar. Concurring with other studies, Dyba found that one of these factors was the "involvement of leadership in the improvement process".

3. Selected Software Engineering Practices

Software Engineering is concerned with producing good quality software in a cost effective way. Software Engineering methods and practices provide guidelines

on how to perform different activities in the software life cycle starting from the requirement analysis, software design, implementation, system testing and installation, project management and system maintenance. In addition there are guidelines on how to improve the software process and how to measure the software quality to allow companies to measure their performance. Applying these methods in any software development industry affects the quality of products of this industry.

In the last decade the software development industry in Jordan has grown very fast. The growing number of companies does not necessarily indicate the existence of a good quality software development industry. This research is investigating whether fundamental good practices in software engineering are being applied in ITC companies in Jordan during the software development life cycle.

Following is a list of what this study considers to be fundamental good practices of software engineering. The survey in this study was designed to measure these practices:

- Producing documents of standard formats during the software development life cycle. The formats need not be confined to theoretical ones only such as UML, but at least internally agreed formats. In addition, updating documents when system changes occur during the system development life cycle or during maintenance.
- Having clear responsibilities and guidelines in the organization on how to perform tasks
- The utilization of CASE tools to improve the efficiency of the software engineering activities
- The existence of a separate project management activity that tracks the software development activities
- The existence of proper communication between team members and with stakeholders
- The existence of a separate software design activity
- The existence of product support after delivery
- The existence of software quality measures
- The existence of practices to measure the performance of the company and to suggest ways to improve it (i.e. Quality control measures)

4. Research Method

A survey was designed to collect empirical quantified data related to the research objectives

4.1 The Questionnaire

The questionnaire had two objectives. First to quantitatively measure the degree of adoption and implementation of fundamental software engineering practices -mentioned in the previous section- in the software development industry in Jordan. The second is to gather information about the status of applications and problems of the software development industry. Examples of information that the research team was interested in gathering were:

- Types of products produced (e.g. customized, off-the-shelf, maintenance of legacy systems)
- Types of applications developed
- Programming languages utilized
- Common difficulties faced in projects
- Requirement analysis methods used to collect requirements
- Design methodologies utilized
- Assignment of programming tasks to programmers
- Responsibilities assigned to project managers
- The quality of the produced products

The proposed questionnaire included nine sections. It was divided into sections to measure software engineering practices in the different stages of the life cycle (requirement analysis, design,

programming, testing, project management, maintenance and support, and quality control). The first two sections were common for all participants, which included personal information and company information. Participants answered sections of the questionnaire that correspond to their job responsibilities in the company. Most of the questions in the questionnaire used a 5 points liker-scale of (Strongly Agree, Agree, Disagree, Strongly Disagree and Doesn't Apply).
Because the questionnaire was intended to gather subjective information, extra questions were included to test the internal reliability.

4.2 Population and Sample

The research targeted ITC companies in Jordan that develop or support software. A list of companies' profiles that work in the IT sector was obtained from Intaj's (Information Technology Association of Jordan) database [9]. Companies that do not develop software and software -related activities were excluded from the final list. Companies that fit the selection criteria were contacted by phone to confirm the profile and the contact details and to get the initial agreement to participate in the study. Seventy companies were found to fit the selection criteria and the rest were discarded, 56 companies agreed to participate in the research. The population included companies of different sizes: small (less than 50 people), medium (50 to 100) and large (greater than 100). Table 1 shows the distribution of company sizes in the sample.

Company size	Count	Percentage
Small	33	58.9%
Medium	6	10.7 %
Large	17	30.4%

Table 1: Company Sizes Distribution in the Sample

Three hundred questionnaires were distributed either manually or electronically within a period of one month. Most of the questionnaires were distributed manually and in most cases they were collected on the spot. An online questionnaire was also designed to allow wider participation of subjects that work on sites outside Jordan. The total number of participants was 265 (245 manual and 20 online), which gives a response rate of 88%.

4.3 Demographic Information about Participants

Two hundred participants were males (78.7%), 54 were females (21.3%), while 11 declined answering this question. Most of the participants of the sample were aged between 22-35 years old (83.1%), while 16 percent were between 35 and 45 years old. 8% of the participants were more then 45 years old and 11 participants declined answering this question. This shows that most of the people working in the IT industry tend to be young.
The sample covered the different activities of the life cycle. Table 2 shows the distribution of the job responsibilities in the sample. (Note that the percentages do not add up to 100 because in some cases participants had multiple responsibilities)

Job responsibility	Count	Percentage
System Analysis	110	41.5 %
System Design	96	36%
Programming	131	49 %
Testing	94	35.5%
Project management	87	33%
Quality Control	54	20%
Maintenance and support	84	31.7%

Table 2: Job Responsibility Distribution in the Sample

The questionnaire also asked about the number of years of experience in the software development. Table 3 shows the distribution of responses to this question in the sample.

Years of experience	Count	Percentage
1- 3 Years	106	42%
4- 6 Years	66	26%
7- 10 Years	40	16%
More than 10 Years	40	16%

Table 3: Years of Experience Distribution

5. Results

Results of the survey showed that a majority of the good software engineering practices were being implemented in most of ITC companies in Jordan. The next section presents the results that show the degree of adoption of the software engineering practices presented in section 3.

5.1 Adoption of Software Engineering Practices

(1) Producing Documents during the Software Development Life Cycle

Four questions in the questionnaire were designed to ask whether the organization produces requirement definition documents, requirement specification documents, design documents and project plan documents. Table 4 shows the percentages of respondents who agreed or strongly agreed that their organization produces such documents.

Question presented	Percentage
Production of requirement definition document	71%
Production of requirement specification document	81%
Production of design document	72.5%
Production of a project plan document	87%

Table 4: Producing Documents During the Life Cycle

However, when enquiring about whether documents were revised and updated when changes are introduced to the software either during the development stages or the maintenance stage, results show a much lower percentages for revising documents. Table 5 summarizes these results.

Question presented	Percentage
Revision of documents during the development process	73 %
Revision of documents during maintenance	53 %

Table 5: Revising Documents

Questions related to standard formats for documents and coding standards had a higher response rate among participants. Note that the questions did not specify a certain standard format; rather any internally accepted format is considered an organizational standard. Table 6 shows the results.

Question presented	Percentage
Standard requirement document format	67%
Standard design document format	64%
Standard project plan format	72%
Coding standards	75%
Code documentation standards	65%

Table 6: Standard Coding and Documents Format

(2) Having clear responsibilities and guidelines in the organization on how to perform tasks

A group of questions were designed to measure this aspect. They focused on four activities of the life cycle: analysis, design, system testing and project management. Results show that there were some forms of guidelines in the organizations for performing these tasks. For instance 82% of the system analyst respondents agreed that they had formal guidelines for performing the requirement analysis tasks. Meanwhile, 72.5% of the respondents agreed that they had formal guidelines for design and 75% had testing guidelines. Project management was divided into multiple measures that will be shortly illustrated.

(3) The utilization of CASE tools to improve the efficiency of the software engineering activities

Results show that some activities in the life cycle were better supported by CASE tools than others. For example there is a deficiency in utilizing CASE tools in the analysis (37%), testing (21%) and project management (32%) activities. Meanwhile,

design activities (53%) and programming (58%) were better supported but not satisfactorily. Among the top most used CASE tools are Microsoft tools like visual studio and Visio, Rational products, and Oracle. It was clearly noticed that Jordanian ITC companies prefer using brand expensive CASE tools over open-source CASE tools.

(4) The existence of a separate project management activity that tracks the software development activities

The questionnaire also checked the existence of formal guidelines that define the responsibilities of the project manager. A surprising result was that although 82% of the project managers participating in the survey agreed that they have a clear list of responsibilities, low percentages accompanied performing any decision making processes. For instance, only 67% were assigned the responsibility of estimating the time schedule and the budget of the project, while 56% were free to choose the personnel to work on the project. These results show that project managers are not participating in some important decisions related to their projects. Another surprising result is the low percentage of managers performing feasibility studies for projects (52%). The previous results may indicate reasons behind the problems faced in IT projects.

(5) The existence of proper communication between team members among themselves and with stakeholders

The questionnaire included several questions to test the existence of feedback between team members during the development process. It also checked the proper communication between the development team and the customers (stakeholders). The following conclusions were reached by the study:

- There were improper communication between team members and customers (e.g. 53% of programmers call customers for clarifications)
- There is a lack of proper communication between customers and analysts (e.g. only 42% of the respondents agreed that they invite the customer to do requirement validation)

(6) The existence of product support after delivery

Results show that product support is highly available and in various forms, such as: training (84%), user manuals (82%), hotlines (74%), and customer visits (60%).

(7) The existence of practices to measure the performance of the company and to suggest ways to improve it

Results show that separate quality control teams exist in approximately 60% of the companies investigated to monitor the development process, evaluate the personnel performance, evaluate the quality of the product and look for ways of improvements. This result is perceived as over optimistic because it contradicts with the next results measuring the quality of the products and the problems faced during projects.

5.2 Status of the Software Development Industry

The second objective of the survey was to gather general information about the current status of the software development industry in Jordan. Results show that most of the products developed in Jordan were maintenance of legacy systems (43%); followed closely by the percentage of customized products (41%). Meanwhile, off-the-shelf products were only 33%. Results that support the same type of conclusions is concerned with the type of programming tasks assigned to programmers: Only 40% write code from scratch, while 68% elaborate on company code and 24% elaborate on external source code.

The top three types of applications developed in Jordan are: Database applications (89%), web applications (86%), and accounting applications (55%). The most utilized programming platforms are: .NET (77%), visual programming languages (VB and C++) (68%) and Java (61%).

Results show that both design methodologies- functional and object oriented- were equally utilized in organizations. Further analysis is needed to check whether companies tend to specialize in one methodology, or flexibly work with any of the available methodologies depending on the project.

5.2 Common Problems Facing Software Development

The most interesting results of the survey are the types of problems faced in the projects and the quality of the produced software. Table 7 shows a summary of the problems faced in projects and their percentage. Moreover, table 8 shows the results concerning quality of the software produced. In the questionnaire we were interested in the following software qualities: maintainability, testability, re-usability, efficiency of code and validity.

Problems faced in projects	Percentage
Projects behind schedule	69%
Projects over budget	44%
Imprecise estimation of resources	44%
Poor visibility of the process progress	30%

Table 7: Problems Faced in Projects

Software quality	Percentage
Software require a lot of maintenance	60%
Errors are difficult to find	46%
When correcting an error, new errors are introduced	37%
Customers are difficult to satisfy	52%
Efficiency of the code	81%
Reusability of the code	78%

Table 8: Produced Software Quality

The poor maintainability and testability of the produced software may be due to the improper utilization of CASE tools during the life cycle, and to the low percentage of documents revision noted in the previous section. It could also be due to improper design. On the other hand, the low percentage of customer satisfaction is probably due to the improper communication between customers and analysts and to the low utilization of CASE tools in the analysis stage as shown by the previous results. The result showing that 38% of the participants agreed that new errors were usually introduced when correcting others indicates that documentation was not being utilized properly during maintenance and that produced documents were not updated as mentioned earlier.

Based on the findings summarized in table 7, the researchers conclude that problems faced in the projects were mainly due to improper project management. One could also conclude reasons that justify this result from other aspects of the survey results. One factor that we discussed earlier is project managers not being involved in main decisions concerning the project (such as personnel selection, and budget estimation). Another factor may be due to the significantly low utilization of project management CASE tools. A third factor could be the lack of experience of the project managers (a striking result that was obtained by cross tabulating the participating project managers with their profiles showed that 12% of the project managers had 1-3 years of experience in the software development, while 22.5% had 4-6 years of experience). Based on previous studies in the literature (some are reviewed in section 2), management is a key success factor in any software development process.

6. Conclusions and Recommendations

This study shows that fundamental software engineering practices are implemented in IT companies in Jordan with varying degrees. Nevertheless, statistical data about problems faced in projects, and the quality of the produced software contradict with the previous findings. This could be due to two reasons: improper implementation of practices or

infrequent implementation of them. For instance, results show the existence of formal guidelines and standard document formats during most of the life cycle activities. However, the questionnaire did not measure how valid or clear these guidelines and standards were. It also did not measure the frequency of applying them. Further research is needed to investigate these aspects.

Furthermore, based on the previous results there are clear weakness areas which need further studies and special attention by those concerned. These areas are:

- CASE tools are not properly utilized in the industry despite their proven benefits. Hence, we recommend that top management of companies should encourage adopting and supporting (by training and help expertise) CASE tools in the ITC sector.
- There is a clear bottleneck in the project management. Hence, we recommend that further studies be conducted to find out the types of skills and experiences project managers have in Jordan, and to identify the reasons behind project management problems.
- Although results show that there is some form of quality assurance teams in organizations, the effects of their work do not seem to be evident in the software process or the product quality. Hence, further studies are needed to investigate in detail the responsibilities of the quality assurance teams and how they actually perform their duties.
- Companies should consider undertaking the Capability Maturity Model (CMM) to evaluate their performances and plan for improvements.
- The fact that a high percentage of IT projects are essentially maintenance of legacy systems indicates that there is a need to widen the software market in Jordan to allow for more challenging projects.

Results of this survey need to be further analyzed to correlate the presented results with the company sizes, personnel experience, company activities and structure. We believe that such analysis will reveal more explanations of the research findings.

References:

[1] "Information Age, Policies and Strategies: An update of Jordan's National Information Policies and Strategies", 2001, http://www.nic.jo/Ar/publications.html.

[2] S. Brilliant and J. Knight, "Empirical Research in Software Engineering: A workshop". Software Engineering Notes, Vol. 24, No. 3, 1999, pp 45-52.

[3] W. Yip et. al., "Critical success factors for the implementation of information center in Hong Kong's banking industry", Proc. of the conference on Organizational computing systems, December 1993, pp 78-89.

[4] J. Herbsleb, D. Goldenson, "A systematic survey of CMM experience and results", Proc. of the 18th international conference on Software engineering, May 1996, pp 323-30.

[5] C. Wohlin, A. Andrews, "Analysing primary and lower order project success drivers", Proc. of the 14th international conference on Software engineering and knowledge engineering SEKE '02, July 2002, pp 393-400.

[6] C. Deephouse, T. Mukhopadhyay, "Software processes and project performance", Journal of Management Information Systems, Vol. 12, No. 3, 1996, pp187.

[7] M. Limayem et al. “CASE Tools Usage and Impact on System Development Performance”. Journal of Organizational Computing & Electronic Commerce, Vol. 14, No. 3, 2004, pp153-174.

[8] Tore Dybå , “Factors of software process improvement success in small and large organizations: an empirical study in the scandinavian context”, ACM SIGSOFT Software Engineering Notes , Proc. of the 9th European software engineering conference, held jointly with 11th ACM SIGSOFT international symposium on Foundations of software engineering ESEC/FSE-11, Vol. 28, No. 5, 2003, pp 148-157.

[9] Information Technology Association of Jordan, http://www.intaj.net