University ERP Preparation Analysis:

A PPU case study

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Abstract— The Enterprise Resources Planning (ERP) systems are one of the most frequently used systems by business organizations. Recently, the university sectors began using the ERP system in order to increase the quality of their academic and administrative services. However, the implementation of ERP is complicated, risky, and no one factor can guarantee a successful system. Previous studies were primarily concerned with Critical Success Factors (CSFs) in business organizations and organizational success factors. This produced plenty of information about these topics. However, the university environment and structure is different, which encourages us to study its specific technical critical success factors. In this paper, Palestine Polytechnic University (PPU) will be our case study. Our attention is concentrated on technical success factors at PPU. Firstly: the paper focused on the technical problems which current systems in the PPU suffered from, in order to extract the particular CSFs which are needed to implement ERP systems. Secondly: the paper focused on the most technical critical factors that ensure successful implementation of the ERP project. Thirdly: a study of the degree to which PPU's technical staff uses software engineering practices during the development process has been conducted by focusing on phases activities. Our main aim is to get a pool of parameters related to a successful preparation of universities' ERP systems.

Keywords— ERP, University ERP; Software engineering practices software Engineering phases activities; Critical success factor; Technical success factors, ERP implementation, successful ERP
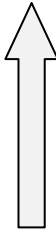
I. INTRODUCTION

Enterprise resource planning (ERP) systems, also named integrated information solutions, or integrated application packages, give us the ability to control all the main functions of a business by using integrated information architecture. The main goal of implementing ERP systems is to connect all units of the business and all organization functions into a unified or integrated computer system that meets the needs and satisfies the users of the entire organization [1]. (ERP) is information system software that aims to integrate all business processes and functions in a central database. This boosts the management of business resources (finance, production, human resource, materials, etc.) in an effective, efficient, and productive way [2] [3] [4] [5]. Moreover, the universities ERP system is defined as "an information technology solution that

integrates and automates recruitment, admissions, financial aid, student records, and most academic and administrative services" [6]. University administrative services include: human resources, billing, accounting, and payroll. On one hand, academic services include deployment, admission, registration, and all aspects of student records [7]. On the other hand, university ERP systems that are implemented for academic purposes provide all administrative and academic functions. Universities have made important investments in ERP implementation in order to improve their business operations planning.

The usage of ERP is not new; it started in the 1960s as accounting software named Inventory Control (IC), in the 1970s it was developed into Material Requirements Planning (MRP) which developed into planning and control of the production cycle. After that, in the 1980s, MRP was advanced in Manufacturing Resource Planning (MRP II) which used to increase the efficiency of manufacturing by technology integrations for information. Then, MRP II extended to ERP systems [5] [8] [9]. Table I depicts the evolution of ERP systems.

TABLE I   ERP EVOLUTION [5]

Year	Chronology
2009	ERP Cloud
2000s	Extend ERP
1990s	ERP
1980s	MRP II
1970s	MRP
1960s	IC

There is no single critical factor that can guarantee the success of the ERP system. ERP requires a mix of critical factors to achieve the desired outcomes. From an ERP point of view, CSFs are the important areas that organizations should focus on in order to achieve successful performance [10] [11] [12]. Previous studies identified plenty of critical factors which had an impact on ERP implementation. These factors

guided, influenced, and helped achieve desired goals. Nonetheless, 60% to 80% of ERP systems failed to meet expected results in the university environment [13]. On the other hand, it will be a way towards failure, when an organization misunderstands of how the software is implemented, and how efficiency and system functionality are to be maintained [14]. In addition to that, ERP system implementation practices will be full of devastating implementation stories. Implementation processes had never been on time, budget, and achieving goals [15]. So researchers define software engineering as "an engineering discipline that is concerned with all aspects of software production" [16]. This paper focuses on the university's situation during preparation for ERP system implementation. In addition, we will concentrate on technical success factors' that influence building ERP at PPU and also the critical success factors that generally conform to gain a successful university ERP in broader context. More specifically, we studied to which degree software engineering practices are used during the software development life cycle process at PPU. The results of the study can be used as guidelines to support the structure that must be followed during the implementation of university ERP systems.

II. UNIVERSITIES' ERP CRITICAL SUCCESS FACTORS

Critical Success Factors (CSFs) are among the important issues that ERP literature focuses on. Approaches and issues of CSFs by case studies were studied, developed, proposed, identified, and analyzed. CSFs are defined as a set of activities which need constant attention in order to plan and implement an ERP system [11]. Despite the differences that exist between organizations' environments, the main categories of technical CSFs discussed in this paper are a concern of almost all universities. In [17] they identified the CSFs in a case study of higher education, and organized factors into categories: organizational, technical, vendor, individual, cultural, social, political and national. Hence, this paper focused on technological aspects. These CSFs include [17]:

1. Complexity
2. Network reliability
3. Flexibility and efficiency of use
4. System's response time to users' requests
5. Data quality, analysis, and conversion
6. Minimum customization
7. User friendliness, help, and documentation
8. Visibility of the system's status
9. Robustness and error prevention
10. Software development, testing and troubleshooting

III. UNIVERSITY SITUATION ANALYSIS-PPU CASE STUDY

We conducted our experiment using qualitative analysis, which entails studying the current phenomenon as real. We saw that qualitative analysis through the form of questionnaires was the best way to conduct this research. Also, we used some quantitative analysis to collect some of the factors to get more specificity to the PPU.

The qualitative method affirms our understanding of situations and allows us to analyze them critically without any bias from information based on previous experiences of the research [18]. Such methodologies are good when the subjects have previous research done in the same area with the same exploratory frame. Quantitative methodology is quite different from qualitative methodology because it affirms and strongly depends on testing and verification. Also, it focuses on facts and hypothesis testing, and is generalizable to the population [18].

A. Study Methodology

This research was conducted by using three questionnaires in total. The first two aimed to study CSFs; one specifically focused on the technical problems which current systems in the PPU suffered from, in order to extract the particular CSFs which are needed to implement ERP systems. The other simply focused on the most technical critical factors that ensure successful implementation of the ERP project. These were extracted from the previous literature and the first questionnaire. The third questionnaire studied the degree to which the technical people utilized standard software engineering practices and activities during the PPU's systems' implementation. After completing the questionnaires, verifying their validity, and measuring their reliability, we printed and distributed them amongst the sample of the study. The completed questionnaires were statistically analyzed and recommendations were extracted.

1) Population
The population studied was technical people at PPU, who are responsible for developing system inside the university.

2) Sample
Consists of (11) technical people who have a significant effect on the development process. Table II shows the demographic information about the sample.

3) Validation of questionnaires
The validity of the questionnaires was verified by presenting it to a group of experienced professors at PPU. They made a number of observations and notes on some of the paragraphs and questions that were taken into account when directing the study in its present form.

4) Study Reliability
To verify the reliability of the study, the internal consistency coefficient was extracted in order to measure the degree to which software engineering practices were utilized during the systems' implementation process at PPU. The Cronbach's Alpha was 94.7%

5) Statistical processing

After collecting the data, we reviewed it in order to prepare and did the required statistical processing. Statistical analysis of the data was done by extracting figures, percentages, mean, standard deviations, and t-test using SPSS.

    6) Scales

- Questionnaire number one and three uses 5 levels Likert scale as: (1=extremely disagree, 2=disagree, 3=undecided, 4=agree, 5=extremely agree).

- Questionnaire number two uses 5 level Likert scale as: (1=extremely not critical, 2=not critical, 3=undecided, 4=critical, 5=extremely critical) in order to study the criticality and importance of factors.

TABLE II   DEMOGRAPHIC INFORMATION

Parameters	*Levels of Parameters*	*Number*	*Percentage %*
Gender	Female	2	18.2
	Male	9	81.8
Position	Managerial Employee	4	36.4
	Technical Employee	7	63.6
Experiment Field	Programmer	5	45.5
	Software Engineering	2	18.2
	Computer Engineering	2	18.2
	Other	2	18.2
Certification Level	Diploma	1	9.1
	Bachelor	5	45.5
	Master	4	36.4
	PhD	1	9.1
Academic University Specialization	Information Technology	5	45.5
	Computer Science	3	27.3
	Network	1	9.1
	Informatics	2	18.2
Experience Years	6 years	1	9.1
	8 years	1	9.1
	9 years	1	9.1
	10 years	1	9.1
	12 years	1	9.1
	14 years	1	9.1
	16 years	1	9.1
	25 years	2	18.2
	31 years	1	9.1
	33 years	1	9.1

B. PPU Case Analysis Results

First: PPU current technical situation analysis.

The aim of this survey is to study the technical problems where current systems at PPU suffer from. These problems are extracted from literature reviews according to the success factors that affect the university's environment and form the internal reports. Each problem is translated into one success factor. Our objective is to specifically investigate the possible ERP factors in this university. The objective of an open question is to indicate additional factors that must be taken into consideration during the implementation of a new system.

The questionnaire includes 18 questions aimed at studying different technical problems of current systems, and how much of the staff actually adheres to the details and concepts associated with the development process.

The subjects of the questions were: complexity, network reliability, flexibility, efficiency, system's response time to users' requests, data quality, analysis, and conversion mechanisms, minimum customization, user friendliness, help menu and documentation, visibility of the system's status,

robustness and error prevention, software development, software testing and troubleshooting [17]. In addition to internal documentation, additional factors are added: data redundancy, process workflow, and System alerts.

To answer the previous question, the mean and the standard deviation of the study questions were extracted as shown in table III.

According to results shown in table IV, the factors which were less than 3 must be taken into consideration. They are: menu and documentation, processes workflows, system alert, and data redundancy.

Table III MEANS & STANDARD DEVIATION OF FIRST STUDY QUESTION

Question	*Success Factor*	*Mean*	*Std. Deviation*
The current systems have no redundant data	Data redundancy	4.2727	.64667
Help manuals, and documentations are always provided to user in the current systems	Menu and documentation	3.7273	1.10371
Processes' workflows in the university are managed correctly	Processes workflows	3.6364	.92442
The current systems are designed to provide useful and needed alerts	System alerts	3.0909	1.04447
The use of the current system is efficient.	System efficiency	2.9091	.83121
The current system was designed to be less complex structures	System complexity	2.8182	.98165
One of the current systems' characteristics is prevention errors	Error prevention	2.7273	1.00905
The current system interfaces are designed to be user friendly	User friendliness	2.64	1.120
One of the current systems' characteristics is robustness	System Robustness	2.6364	1.12006
The current system was designed to be flexible.	System flexibility	2.5455	.68755
The current systems have an easy data conversion mechanism	Conversion mechanisms	2.4545	1.12815
The current system responses to user's requests quickly	System's response time to users' requests	2.4545	.93420
The current system's status is an aspect is always you concern to be visible to user	Visibility of the system's status	2.3636	1.12006
The current systems are highly customized with business processes	Minimum customization	2.3636	.92442
The current systems are tested	Software testing and troubleshooting	2.0909	.83121
The network in the current system is reliable.	Network reliability	2.0000	.63246
Frequent development and testing are activities that current systems reveal.	Software development and testing	1.9091	.53936
A good data quality is a feature that took under consideration when provided to the current systems' implementation	Data quality	1.8182	.98165

Consequently, the factor of process workflows is converted to the Business Process Reengineering (BPR): because there must be a change of some of the work processes to optimize the implementation of ERP systems [6]. The factor of data redundancy was merged with system integration because it will be eliminated when the integration is achieved, so it is converted to system integration. Also, the system alert merged with system integration because the needed alerts will be

provided and automated easily when integration is successfully accomplished. In the "undecided answers" pool, we noticed that there was a problem of technical people not being able to choose answers regarding their systems' aspects, specifically the systems that they themselves are working on. Consequently, we decided to cover the factors which earned a high rate of undecided (>2.5). They were: System efficiency, System complexity, Error prevention, User friendliness, and System robustness.

Moreover, the questionnaire also included open questions that sought additional factors that the staff thought must be considered as technical aspects of the systems at PPU. The results were:

1. Security.
2. IT infrastructure.
3. Business process reengineering.
4. Applying software engineering standards.
5. Database administrator.
6. Using unified theme of technology.
7. System integration.
8. Training.

Hence, according to table IV, the literature review, internal documents, and response of the interviewees to the questionnaire and interview, we found that the critical success factors which we should be concerned with when studying the implementation of new ERP systems in PPU are:

1. Complexity.
2. Efficiency.

3. Data analysis.
4. Help menu.
5. Documentation.
6. Robustness and error prevention.
7. Security.
8. IT infrastructure.
9. Business process reengineering.
10. Applying software engineering standards.
11. Database administrator.
12. Using unified theme of technology.
13. System integration.
14. Training.

Second: Technical CSFs for PPU case.

The aim of the second questionnaire was to study the question of "which critical factors were the best at ensuring the technical successful ERP project implementation". These factors were extracted from the first questionnaire and literature review as explained in the previous section. Table IV was created which includes the results of the mean and the standard deviation for each technical factor.

The table VI shows that the dominant answers were between "agree and extremely agree". In order to verify which critical success factors at PPU were more critical and effective, the sample t-test method was used, where the null hypothesis H0 is $\mu<3$ and the alternative hypothesis H1 is $\mu\geq3$. Following t is the used statistic test [6]:

$$t = \frac{x-3}{s/\sqrt{n}} \qquad (1)$$

TABLE IV   MEAN & STANDARD DEVIATION OF CRITICAL SUCCESS FACTORS FROM TECHNICAL PERSPECTIVE IN PPU

	Factor	*Mean*	*Std. Deviation*
1.	Security	4.9091	.30151
2.	System integration.	4.6364	.50452
3.	Data analysis	4.6364	.50452
4.	Database administrator	4.4545	.52223
5.	Efficiency of use	4.4545	.52223
6.	Complexity	4.4545	.52223
7.	Robustness and error prevention	4.3636	.50452
8.	Business process reengineering	4.1818	.87386
9.	IT infrastructure	4.1818	.40452
10.	Training	4.0909	.30151
11.	Applying software engineering standards	3.9091	.94388
12.	Documentation	3.7273	1.10371
13.	Using unified theme of technology	3.6364	.67420
14.	Help menu	3.5455	.82020

The results of questionnaire are shown in table V.

TABLE V   THE T-TEST

Factors	Test Value = 3	
	t-test	p-value
Security	21.000	.000
Training.	12.000	.000
Data analysis	10.757	.000
System integration.	10.757	.000
IT infrastructure	9.690	.000
Database administrator	9.238	.000
Complexity	9.238	.000
Efficiency of use	9.238	.000
Robustness and error prevention	8.964	.000
Business process reengineering	4.485	.001
Applying software engineering standards	3.194	.010
Using unified theme of technology	3.130	.011
Help menu	2.206	.052
Documentation	2.185	.054

Therefore, according to the questionnaire results which were shown in table V; the 14 critical and effective CSFs of ERP implementation in PPU, arranged from more critical to less critical, which are:

1. Security.
2. Training.
3. Data analysis.
4. System integration.
5. IT infrastructure.
6. Database administrator.
7. Complexity.
8. Efficiency of use.
9. Robustness and error prevention.
10. Business process reengineering.
11. Applying software engineering standards.
12. Using unified theme of technology.
13. Help menu.
14. Documentation

Third: PPU current software engineering situation analysis.

The aim of this questionnaire is to study the degree of software engineering activities which are utilized during systems process implementation at PPU. All theoretical information is extracted from [16].

1. Software Specification or Requirements Engineering

Requirements engineering activity is the process that is responsible for developing and extracting software requirements. The specifications are designed to communicate the system needs of the users with system developers.

In our research, we studied main sub-activities that must be done during this phase. These include:

1. Feasibility study.
2. Perform elicitation and specification of requirements.
3. Making a scenarios and prototype constructions.
4. Constructing system models.

The percentage PPU technical staff utilizing this stage was 41.9%. Results of mean and standard deviation for sub-activities that were included in the phase of software specification are represented in table VI. The results are listed in order from the most to the least applied. Looking at the data, the feasibility study is the activity that is most applied. Here, according to [16] elicitation requirements will keep us away from facing problem and errors in the next stages.

TABLE VI   SOFTWARE SPECIFICATION PHASE RESULTS

Software specification activities	Mean	Std. Deviation
Feasibility study	3.5000	1.26930
Constructing system models	2.7273	1.00905
Making scenarios and prototype constructions	2.7273	1.00905
Perform elicitation and specification of requirements	2.4545	.82020

2. Software Design

The next stage that our research deals with is software design, in which design face describes the structure of the system intended for implementation, indicates data models which will be used, and determine interfaces between components ...etc. In our research, we studied the main sub-activities that must be carried out during this stage. they include:

1. Applying an architectural design.
2. Applying an interface design.
3. Applying a component design.
4. Applying a database design.

The percentage of PPU technical staff utilizing this stage was 40.9%. The results of mean and standard deviation for sub-activities that are included in this phase can be found in table VII. The results are listed in order from the most to the least applied. Looking at the data, the architectural design is the activity that is most frequently applied.

TABLE VII   SOFTWARE DESIGN PHASE RESULTS

Software design activities	Mean	Std. Deviation
Applying an architectural design.	3.0909	1.30035
Applying an interface design.	3.0000	1.18322
Applying a component design.	2.9091	1.22103
Applying a database design.	2.0909	.94388

3. Software development

The software development stage is responsible for converting system requirements and specifications into an executable system during the process of software development. In our research, we studied main sub-activities that must be carried out during this stage. They include:

1. PPU project developers' team members.
2. PPU technical team members who are well skilled
3. Availability of technology tools which support the capabilities and productivity.
4. Making system documentations.
5. Conversion plan.

The percentage of PPU technical staff utilizing this stage was 45.5%. The results of mean and standard deviation for sub-activities included in this phase can be found in table VIII. According to results, we see that "Availability of technology tools which support the capabilities and productivity" is too low which indicates that the staff needs more resources besides the skills which must be developed.

TABLE VIII   SOFTWARE DEVELOPMENT PHASE RESULTS

Software development activities	Mean	Std. Deviation
A high turnover rate of the project developers' team members	3.4545	1.21356
Making system documentations	3.3636	1.12006
Having a conversion plan	2.8182	.98165
PPU technical team members are well skilled	2.3636	.67420
Availability of technology tools	2.2727	.46710

4. Verification and Validation

Software validation is the process of verifying that the system complies with its specifications and it meets the real needs of system users. In our research, we studied the main sub-activities that must be carried out during this stage:

1. Test plan
2. Development testing
3. System testing
4. Acceptance testing

The percentage of PPU technical staff utilizing this stage was 45.5%. The results of mean and standard deviation for sub-activities that are included in this phase are shown in table IX. The results are listed in order from the most to the least applied. Looking at the data, creating a test plan is the most applied activity.

TABLE IX   VERIFICATION AND VALIDATION PHASE RESULTS

Verification and Validation activities	Mean	Std. Deviation
We always have a test plan	2.8182	.98165
We always do development testing	2.8182	.98165
We always do acceptance testing	2.5455	.82020
We always do a system testing	2.4545	.93420

5. Project management

All systems should be developed using a clear development process. The university must plan the development process and have clear and complete ideas about what will be developed and what is the outcome of the development process and when it will be completed. Accordingly, we decided to focus on the project management as a stage. In our research, we studied the main sub-activities that must be done during this stage which include:

1. Determine project's activities by milestones
2. Frequently sending the project progress reports to the manager by employees
3. Setting project schedules (e.g. activity chart, bar chart)
4. Creating project risk management plan

The percentage of PPU technical staff utilizing this stage was 40.9%. The results of mean and standard deviation for sub-activities included in this phase can be found in table X.

TABLE X   PROJECT MANAGEMENT PHASE RESULTS

Project management activities	Mean	Std. Deviation
Setting project schedules (e.g. activity chart, bar chart).	3.4545	1.03573
Creating a project risk management plan.	3.2727	1.19087
Determine project's activities by milestones.	2.8182	.98165
Frequently sending the project progress reports to the manager by employees.	2.6364	.92442

As summery, table XI represents the fundamental software engineering activities for any software development process which done by PPU staff. They are listed in descending order from most to least applied. We concluded that the most

applying activity is project management, then software development, after that software specification, then software design. At the table shows that verification and validation activity to be the least applied.

TABLE XI   TOTAL RESULTS

	Mean	*Std. Deviation*
Project management.	3.0455	.82778
Software development.	2.8545	.57335
Software specification.	2.8182	.88099
Software design.	2.7727	1.05744
Verification and validation.	2.6591	.76053

IV. CONCLUSIONS

Enterprise Resource Planning (ERP) or integrated information solutions provide a controlling ability to all main business functions of organizations and companies using integrated information architecture. Thus, universities exploit ERP system to take its advantages and to improve the information systems they possess. In this paper, we took Palestine Polytechnic University (PPU) as a case study in order to help preparation of ERP implementation, and to improve the information system at PPU. The current situation is fragmented and non-integrated system, in addition to different data identification and redundancy.

This paper focused on the university's situation during the preparation of ERP system implementation. In addition, the study concentrated on technical success factors' influenced on and important to PPU case. The critical success factors that generally conform to gain a successful ERP system are also mentioned. More specifically, we studied the degree that software engineering practices are used during the software development life cycle process at PPU. The results of the study were used to support the structure that must be followed during the implementation process. The final list of technical CSFs of PPU includes:

1. Security
2. Training.
3. Data analysis.
4. System integration.
5. IT infrastructure.
6. Database administrator.
7. Complexity.
8. Efficiency of use.
9. Robustness and error prevention.
10. Business process reengineering.

In the case of software engineering practices, we found that the most applying activity is project management, then software development, after that software specification, then software design. At the end we find verification and validation activity is the least applied.

A potential future work is to empirically use these results to improve a PPU's ERP framework in order to prepare and plan to implement an efficient ERP system.

V. ACKNOWLEDGEMENTS

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