Palestine Polytechnic University

Deanship of Graduate Studies and Scientific Research

Master of Informatics

A Proposed Framework for University ERP Implementation

Case Study – Palestine Polytechnic University (PPU)

Submitted by:

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Thesis submitted in partial fulfillment of requirements of the degree

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DEDICATION

To

My mother a strong and great soul for your encouragement and continuous care

My father for earning an honest living for us, the reason of what I become and reached today.

Thank you for your support

To my brothers and sisters

To my real friends whom stands beside me.

To those all strong women and mothers throughout the long past ages

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I would like to thank my family for their continued support, encouragement and patience from the first step till the end. As I write the last words of this thesis, I greatly appreciate the thesis's supervisors Dr. Radwan Tahboub and Dr. Faisal Khamayseh for their continuous support and time they spent with me in order to succeed this thesis.

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Thank you so much for a great experience.

الملخص

أصبح نظام تخطيط موارد المؤسسات يُستخدم على نطاقٍ واسع في جميعِ أنحاء العالم؛ في البداية كانت هذه التكنولوجيا تقتصر على الشركات الربحية وذلك لتحسين أدائها وإدارة وظائفها لزيادة أرباحها. في الآونة الأخيرة، بدأت الجامعات بتطبيقِ هذا النظام والاستفادة من مَيزاته، من أجلِ تحسين القدرة على السيطرةِ والتحكم على وظائفِهم الأكاديمية والإدارية. بالإضافة إلى أتمتة ودمج عمليات ووظائف الجامعات، وتبادل البيانات.

المفهوم الأساسي لنظام تخطيط موارد المؤسسات هو التكاملية؛ والتي يمكن أن تتحققَ من خلالِ استخدام قاعدة بيانات مركزية تجمع بين جميع برامج الأقسام الاخرى. وعموماً، يحتوي نظام تخطيط موارد الجامعات على حُزَم تدعم إدارة شؤون الطلاب، وإدارة الموارد البشرية، والمكتبة، والعمليات المالية، وإدارة الأصول، والتعليم الإلكتروني، والأبحاث، ومراقبة الطلاب.

والمشكلة هي أن نظام جامعاتنا المحوسب هو عبارة عن مجموعة من الأنظمة المجزأة، أي ان لكل قسم في الجامعة لديه نظام منفصل عن الآخرين. وقد خلق هذا التجزؤ العديد من المشاكل، مثل: التعريف المتعدد للبيانات، عدم وجود نظام متكامل، وتكرار البيانات ... الخ.

في هذه الأطروحة، أخذنا جامعة بوليتكنك فلسطين كحالة للدراسة، وذلك لدراسة و تحليل واستكشاف العوامل التقنية لنجاح تطوير البرامج في محاولة منا لزيادة نجاح نظام تخطيط موارد المؤسسات في الجامعات ، وذلك من أجل زيادة الوعي والمعرفة بعوامل النجاح و تطبيق الممارسات البرمجية الصحيحة، بالإضافة إلى دعم معرفة الموظفين حول أنشطة هندسة البرمجيات وعمليات إنتاجها.

بعد تحليلٍ ودراسة العوامل التقنية للنجاح قمنا ببناءِ نموذج تنفيذي لنظام تخطيط موارد المؤسسات لجامعة بوليتكنك فلسطين. أما الأدواتُ التي استُخدمت لإكمال هذه الأطروحة بنجاح هي: الإستبيانات والمقابلات والمعلومات المختلفة التي تم جمعها من المقالات والكتب والوثائق الداخلية للجامعة والتقارير ومواقع الانترنت

النتائج الرئيسية للرسالة هي: خلق وتحسين المعرفة قبل البدء بتطوير نظام تخطيط موارد المؤسسات ، بالإضافة إلى تسليط الضوء على نقاط العمل التقنية التي يجب أن تهتم بها الجامعات قبل البدء في العملية التطويرية. وعلاوة على ذلك، فإن إنشاء نموذج لتنفيذ وتطوير هذا نظام يُعتبر هذا النموذج مرشداً توجيهياً يوضح عملية التطوير للحد من إمكانية حدوث مشاكل قد تنشأ عن تغيير النظام.

Abstract

Enterprise Resource Planning (ERP) systems are widely used systems across the world. At the beginning, they were business organizational technology, which are used to improve companies' performance and to manage their functions in order to increase the profit. Recently, universities started to implement the ERP systems to exploit it to improve the ability of controlling their academic and administrative functions.

The core concept of the ERP is the integrity, when using a centralized database to combine all organization's departments' software. University's ERP contains modules to support student management and administration, management of human resources, library, e-learning...etc. But, our university suffer from the fragmented computerized systems, as each department has a separated system. That created several problems, such as multiple identifications of data, no integrated solution, and data redundancy.

In this thesis, the Palestine Polytechnic University is our case study in order to analyze and explore the technical success factors to attempt increasing the implementation success of university ERP system. After exploring technical success factors, we built an implementation framework for PPU's ERP system.

The main two results of the thesis consist of creating and improving a pre-implementation knowledge about ERP systems, in addition to highlight the action points about which technical success factors must the university concern before starting ERP implementation. So, creating an ERP implementation framework that considered a guideline that clarifies the implementation process to reduce the possibility of problems that may arise from changing the system.

Contents

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List of Abbreviations

ERP	Enterprise Resource Planning
MRP	Material Requirements Planning
MRPII	Manufacturing Resource Planning
CSF	Critical Success Factor
BPR	Business Process Reengineering
IT	Information Technology
HR	Human Resource
CRM	Customer Relationship Management
SRM	Student Relationship Management
SCM	Supply Chain Management
MRM	Manufacturing Resource Management
SAP	Systems, Applications and Products in Data Processing
IC	Inventory Control
ROI	Ratio of Investment
PPU	Palestine Polytechnic University

Chapter 1

Introduction

1.1 Background

Enterprise Resource Planning (ERP) systems also named integrated information solutions are one of the biggest and the most important areas of the development of information systems in the business field [1]. ERP systems give us the ability to control all main functions of the business in the organization through using integrated information architecture. The main objective of implementing ERP systems is to connect all units of the business and all organizational functions into a unified integrated information system, which meets business needs and satisfies the users of the entire organization [1].

Generally, ERP systems include different software modules to guarantee the automation and integration of business functions, by accessing, sharing, practicing information and data in real-time, improving process flow, getting better data analysis, and improving the business performance. Moreover, the most important concept of the ERP system is a central database, using a single database greatly simplifies information flow across the organization. So, the information will be entered only once, and then it will be available for all users with real-time

updates [2–5].

ERP system increases the accessibility of information as it allows doing different activities in parallel form. Therefore, automation and integration of business process in ERP helps to perform different activities and allow faster access to information [5, 6].

Recently, universities started to exploit business packages for managing their processes and technologies in order to increase their performance and controlling cost and services. In addition to integrate and automate their processes, such as student records and admission [7] and improved the quality of managing resources, improved the efficiency of operation, and increased universities' competitive advantages [8]. Therefore, universities or higher education institutes are more willing to adopt the ERP systems, which help them acquiring the desired advantages of ERP systems [9].

On the other hand, universities spent more than five billion dollars for the investment of ERP systems during the years. Lately, vendors started to expand their products range to include new applications to meet the requirements of universities' market; e.g. a management application for student life cycle from Oracle and SAP [10] . The essence of the system generally contains modules which support a student management and administration such as the registration procedures. Management of human resources such as controlling staff. Financial issues such as accounting and payments. Besides, the ERP system can include more advanced features of some other applications, such as e-learning [11].

Thus, one critical factor will not guarantee the success of the ERP systems implementation as it needs a mixture of critical factors to achieve the desire decisions. From an ERP point of view, CSFs are the number of significant factors, activities, and key areas that organizations should focus on and give it a special consideration in order to achieve a successful performance, and help in planning and implementing the ERP system [2, 12, 13]. Literature studies identified a plenty of critical factors, which have an impact on ERP implementation, these factors guide, influence, and help to get the desire goals. Nevertheless, 60% to 80% are the failure of ERP systems of meeting the expected results in university's environment [9].

That fact that ERP system implementation practices were full with devastating implementa-

tion stories, as the system has never been on time, budget, and achieving the goals [14]. That will happen when organization miss the understanding of the software implementation, how to keep the system efficient and maintain its functionality, then the systems will be useless [15]. So, [16] defined that the software engineering includes the process, methods and tools, which enable the combination of computer systems to be developed in time and quality. In addition, researchers defined the software engineering as "an engineering discipline that is concerned with all aspects of software production [17]".

1.2 Research motivation- universities problem

After studying the university system and internal documents we concluded that the fragmented systems are the main problem that our university systems suffer; as each department has separated system from others, which leads to several problems, such as:

- Multiple identifications of data in each system.
- No integrated solution that controls the data flow.
- Lack of administrative and academic services.
- Manual operations.
- Low quality and time of performance.
- Data redundancy.

As a result for the above-mentioned problems, universities started to adopt and implement an ERP system to solve the problems occurring in their old fragmented systems. In addition, the universities attracted to adopt ERP systems because of global trends, increasing in students' numbers, the learning environment and competitive between universities, and the need for quality and performance. This forces university's decision makers to think about developing and replace the university systems with ERP, which provide a useful management tools, user accessibility, and increase performance [4]. All these advantages encouraged the adoption of ERP systems to be involved strongly to the competitive market [4].

In addition, ERP systems' implementation, performance, success, and circumstances in business organizations have been studied and researched during last decade. Still many publications are needed in the field of ERP implementation in universities' environment [9].

Because of that, the researcher got more interest to study the environments of universities that will implement ERP system packages. According to the PPU's circumstances, our universities need to find out a pre-development analysis that includes the solid knowledge, which is related to the ERP development process and CSFs that are highly connected with their environment. Therefore, system pre-implementation preparation is considered one of the ERP success keys that must have our concern and perform. So, one of our thesis objectives is to provide a complete understanding of the ERP CSFs, benefits, risks, challenges, usage, universities' environment, and functional issues and spot the light to the ERP adoption, selection, packages, and implementation.

1.3 Statement of the problem

The activities, methodologies, and tools which will be used during the implementation processes is one of the key factors that affect a successful system implementation [18]. Also, the implementing of the ERP system is a big challenge because it has a lot of dimensions which are affected by the success of this type of integrated systems [19, 20]. It is important to consider how to deal with the ERP development projects, what must be done to make it possible while considering the ERP implementation strategies, methods, techniques, and the differences between approaches. Thus, we need a framework to organize how to deal with implementing an ERP system [14, 20–22]. Recently, the universities became more willing to adopt the ERP systems, which help them managing and integrating their processes and technologies to increase the performance and controlling cost and services and acquiring the desired advantages of the ERP systems [7, 9]. By studying the system and the internal documents of the PPU, the fragmented systems were the main problem that the university systems suffer from [23]. As every departments in the university has its own separated system, which leads to several problems. To override the problems, the research covered three main sections; to explore the technical CSFs; when implementing an ERP system must need to think of the CSFs and because of the complex

nature of the ERP system the one critical factor will not guarantee the success of the ERP systems implementation so it needs a mixture of critical factors to achieve the desire decisions [12], this research study the technical CSFs which are particular for PPU University as few studies are only specialized for university trying to building a good IT infrastructure. In addition, to help PPU to prepare for implementation the ERP system in order to improve their computerized system. To help the PPU applying the ERP system with a systematic approach and standardized methods, which are extracted from the software engineering practices and the ERP solution. Then to reflect this knowledge into a framework, this framework is a well-planned implementation stage, which are essential and required to ensure the feasible development and the success of the PPU's ERP system [22]. Finally, to create an evaluation plan in order to insure the satisfaction of the users after three years of effective usage.

1.4 Research objective and scope

The main aim of the ERP system is to integrate all the organization's departments and procedures across it to a centralized database, which serves all departments and all of their functions and needs. Each department has to install a particular system to perform their work. Then the ERP systems integrate all software programs to ease the communication and sharing information between departments [24].

As the number of students, employees, lectures, and assets of universities are increasing, controlling of the universities' resources and process' became more complex. Therefore, the need of the ERP systems increased to support the concept of systems and data integration, helping decision making, and support enterprise evolution. In fact, the main objective of implementing ERP systems in universities is for academic purposes rather than profit [11].

The general objective of this thesis is to provide ERP system information that is related to the universities. The main goals of this thesis are:

1. Exploring and analyzing the existing and the current knowledge of literature about ERP system implementation and factors of success.

2. Studying and analyzing the difference between business ERP system and university ERP system.

3. Defining the benefits and impacts of universities ERP.

4. Examining the university current situation and system by studying the PPU's environment as a case study.

5. Identifying CSFs of ERP systems that are related to the technical and software engineering perspective which are coupled with universities' environment.

6. Constructing a framework to ease the implementation of ERP systems in PPU.

1.5 Contribution

The main contributions of this thesis are summarized as follows:

1. A rigorous concentration of university's technical success factors of ERP implementation in existing literature.

2. Identifying technical success factors as specific topic in order to acquire a successful ERP implementation by studying the PPU case study.

3. Exploring and re-engineering the technical success factors for PPU's ERP system.

4. Proposing a university ERP system framework based on software engineering practices and CSFs point of view.

1.6 Research flow

The research methodology includes five main activities, as illustrated in Figure1.1:

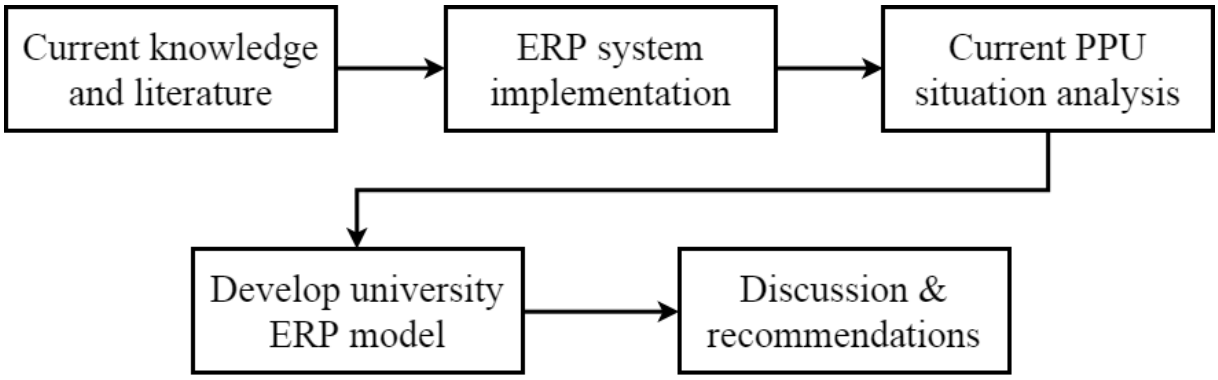

Figure 1.1: Research Flow

1. Current Knowledge: Business ERP system vs. university ERP system.
    - Definitions: Business ERP system and university ERP system.
    - ERP system evolution.
    - Business ERP system modules vs. university ERP system modules.
    - Business ERP system architecture vs. university ERP system architecture.
    - ERP systems Advantages and disadvantages in both business organizations and universities.
    - ERP system risks and challenges.
2. ERP system implementation
    - System development using software engineering point of view
    - ERP system implementation strategies, topics, practices and activities.
    - University ERP system frameworks.
    - Critical success factors−technical factors.
3. Develop university ERP framework
    - Internal documents.
    - Questionnaire
    - Interviews
4. Developing a university ERP implementation framework for PPU

5. Discussion and recommendations

1.7 Publications

The authors publications are:

1. ”ERP Systems Critical Success Factors ICT Perspective”, International Journal of Advanced Computer Science and Applications (IJACSA), pp. 191-196, 2015.

2. ”University ERP Preparation Analysis: A PPU case study”, International Journal of Advanced Computer Science and Applications (IJACSA),pp. 345-352, 2017

3. The paper of: ”A Proposed Framework for University ERP Implementation: A Case Study of Palestine Polytechnic University ” was submitted to acceptance at journal of theoretical & applied information technology.

1.8 Thesis structure

The remaining parts of the thesis are organized as follows: chapter 2 presents the university case study (PPU), chapter 3 contains the ERP system background and the difference between business ERP system and university ERP system. Chapter 4 describes ERP system implementation and critical success factors. Chapter 5 covers methodology and the our PPU case study. Chapter 6 demonstrates results & Discussion of university ERP framework and recommended CSFs and proposed practices. Finally, Chapter 7 concludes the work and proposes some new direction for the future work.

Chapter 2

The university case- Palestine Polytechnic University (PPU)

Palestine Polytechnic University (PPU) was established in 1978 by the University Graduates Union (UGU) in Hebron-Palestine. PPU mission is to assure the quality of the vocational and the technical engineering education, which is achieved by providing students with enough practical knowledge to help them gaining the latest experience directly related to their disciplines [25].

PPU offering some of degrees: two years diploma degree, Bachelor degree in numbers of engineering programs. Moreover, there are numbers of master degrees such as: master of informatics and master of bioinformatics [25].

There are about 6300 students enrolled in the different areas of PPU specializations during the academic year 2016/2017. Also, PPU raise certain services, strategies and programs to meet the community priorities and needs. The PPU faculties are: [25]

- Faculty of engineering including the departments of: Electrical engineering, mechanical

engineering, and department of civil and architectural engineering.

- Faculty of information technology and computer engineering including the departments of: computer engineering and information system, and information technology and computer science.
- Faculty of applied science including the departments of: applied mathematics and physics, and applied chemistry and biology.
- Faculty of applied professions that includes the departments of: engineering professions, administrative sciences, computer sciences.

In addition, to the deanship of scientific research, deanship of students affairs, public relations department, department of admission and registration, quality assurance unit, department of continuing education, Fawzi Kawash center for excellence in information technology, industrial synergy center, vehicles testing center, stone and marble center, COSHEP, and department of technical consultancy and specifications.

2.1 Why should PPU adopt ERP system?

The nature of the university environment is a dynamic and change rapidly, wherefore the ERP system is an appropriate work, which can enhance and transform to meet different needs of different users [21].

As known, the ERP system refers to the commercial solutions, but PPU intends to utilize the benefit of this solution to support an administrative and academic purposes. Therefore, the most important reasons which makes PPU adopt the ERP system solutions are ”to improve the services of students, process’s transformation in the university, modernized computer systems, improved management, preserving competitiveness, and improved operating efficiency [24]”, decrease costs, improving management, integration, and eliminating system fragmentation.

2.2 The current systems situation

According to the internal documents of the PPU and what is presented by the software integration committee at the PPU [23] we concluded and identified the suggested status of PPU as shown in Table 2.1.

Table 2.1: Current PPU's problems

	Problems
Technical staff properties	Low number of professionals in software engineering development. Lack of high experienced software engineering analysts. Lack of leadership in the software engineering development lifecycle. Lack of database administrators.
Administrative properties	Lack of real plans. Lack of clear ICT manager. High academic and work load of existing ICT staff
Current services	Does not clearly support new PPU mission and vision. Does not support decision support activities. Minimal documentation and manuals.
ICT organizational structure	Lack of high level clear ICT organizational structure to supports the development of the ERP system.
Financial aspects	Lack of high budget allocation for the required ERP systems
ICT decision making strategies	Lack of integrated mechanisms to handle a high level of ICT integrated systems
Other issues	High work load of all PPU users. Change management issues by some units, users and students. Poor of training. No clear decision regarding University ERP buy or build strategies.

2.3 The current PPU systems structure

According to the internal documents of the PPU and what is presented by the software integration committee at the PPU [23] we found that the systems there have a fragmented structure as shown in Figure 2.1. There are 27 systems in the PPU, where only 4 are connected. Thus, no one integrated solution is there.

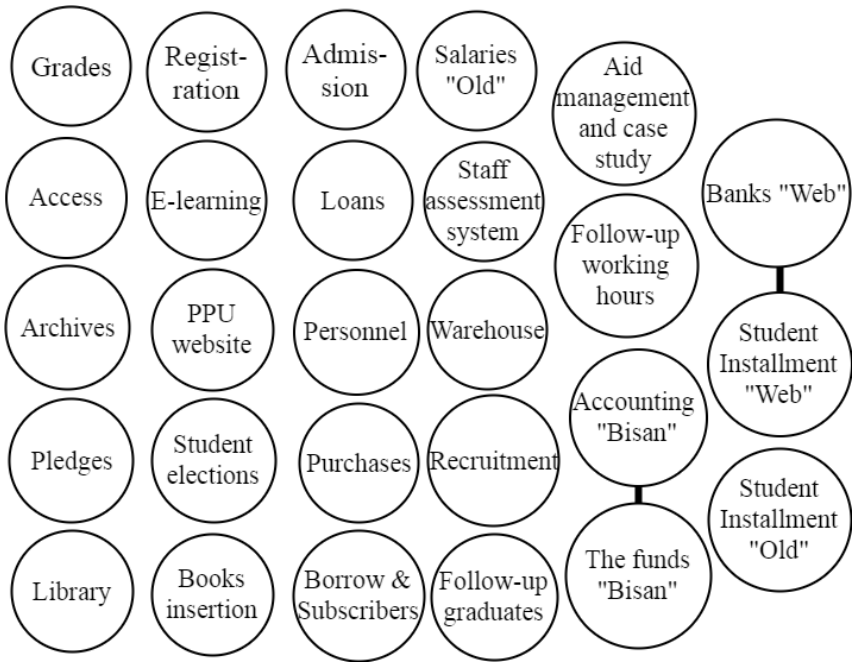

Figure 2.1: Current PPU's systems

After studying Table 2.1 and Figure 2.2 that are extracted from the PPU's internal documents [23], we noticed that there are a lot of problems related to different dimensions across the university: technical, financial, administrative... etc. Thus, the fragmented systems will suffer from a huge number of problems which will adversely affect the university. The systems are not connected with each other, and the data defiantly redundant, in addition to the different definition of the same data in each system.

2.4 The PPU's ERP system

The PPU's ERP system must be as the Figure 2.2. The needed modules are [11, 23] :

1. Student life-cycle (this module responsible for supporting student life-cycle processes): admissions and academics, student fees, placement service portal, and students self-service portal.

2. Academic services (contains functions that manage the academic processes across the university): library management, e-learning, employees self-service portal, research project and master thesis.

3. Enterprise management (contains functions for supporting the educational institutions' development): financial, budget management, HR and payroll management accounting, Stores, purchase, bill, and assets.

4. Administrative services (contains functions for supporting the administrative staff): legal issues, reports and document management.

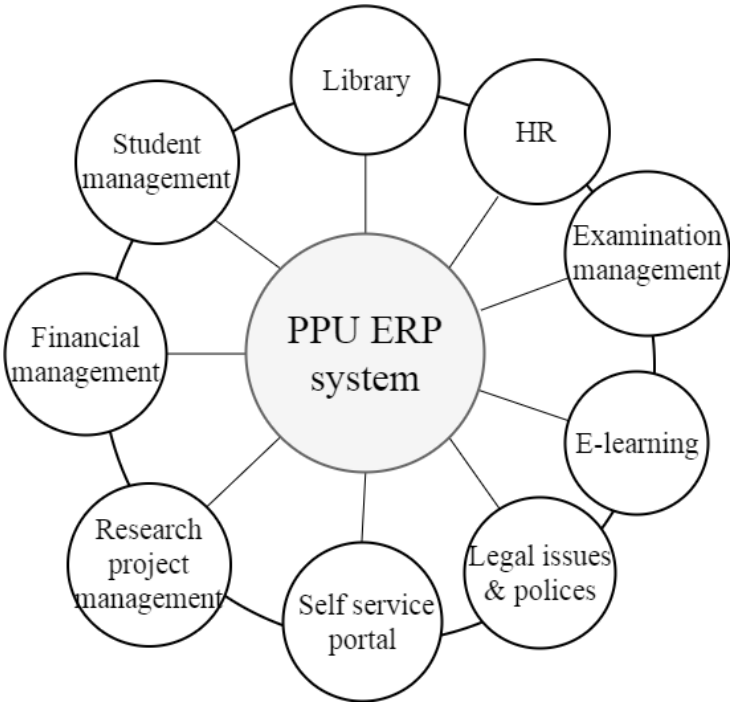

Figure 2.2: PPU's ERP

Chapter 3

Business ERP System vs. University ERP System

This chapter presents a background required to understand the rest of the thesis and explains the difference between business ERP system and university ERP system. The first section explains the definitions of business ERP system vs. university ERP system. The second section explains the evolution of ERP system. The third section of this chapter describes business ERP system modules vs. university ERP system modules. The forth section about business ERP system architecture vs. university ERP system architecture. The fifth and sixth sections explain advantages and disadvantages of ERP system. The final section covers the ERP risks and challenges.

3.1 Definitions: business ERP system vs. university ERP system

Business Enterprise Resource Planning (ERP) systems also named integrated information solutions or may called integrated application packages; give us the ability to control all the main functions of the business in the organization 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 which meets the needs and satisfied the users of the entire organization [1].

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 [4]. University administrative services include: human resources, billing, accounting, and payroll. On the other hand, academic services include deployment, admission, registration, and all aspects of student records [24].

The researchers in [26]indicate the similarities and differences, which are related to the universities and other business organizations in order to refashioning universities' identity. Therefore, universities considered themselves as separated ”sector” or ”community” that have special requirements and needs, in which must be distinguished with their different operations from the traditional business organizations [26]. So, the standard ERP packages are not suitable for university environment [19].

Clearly, the differences between university ERP systems and business ERP systems are obvious because the universities implement ERP for an academic purposes therefore it is considered nonprofit purposes in contrast to organizations they are exploiting ERP system for business purposes and earning profit [4].

3.2 ERP system evolutions

Enterprise resource planning is not a new concept, it starts in the 1960s where it was a software for inventory management and all packages had a purpose of controlling the inventory's

functions, and was named Inventory Control (IC) Packages, until 1970s, Material Requirement Planning (MRP I) systems were developed to plan a production, controlling the inventory, atomization the order of purchasing, and purchasing director. These packages contained a bill and production schedules where they were integrated and planned activities [27]. The next generation of (MRP I) was Manufacturing Resource Planning (MRP II) in 1980s, where developed in order to have advanced systems [28].

In general, it had the basic functions of MRP I but added additional features, more focusing on the quality and developing the schedules, monitoring the production plans, and more focusing on user satisfaction [27]. MRP I and MRP II are solely concentrating on increasing the performance and efficiency of a particular part of the system which different from ERP system, it is focus on the whole of organizations' parts [29] this lead up to ERP that we have nowadays. In 1990s ERP began and the sharing of information is spread and the functions of the organization were integrated, also during the years the ERP itself is coupled with new technologies to improve the functions that are offered such as cloud ERP [30]. So, the use of ERP system increased and the revenue of ERP around the world [31]. Table 3.1 illustrates the evolution of ERP system [30].

Table 3.1: Illustrates the evolution of ERP system [30]

Year	Chronology
2014	Mobile ERP
2009	ERP Cloud
2000s	Extend ERP
1990s	ERP
1980s	MRP II
1970s	MRP
1960s	IC

3.2.1 Cloud ERP system

Cloud ERP appeared and defined as a combination of ERP software by implementing it on cloud provider; until to acquire utility of both cloud computing and ERP systems to improve and organize all the companies' processes and data [32]. A comparison between traditional ERP and cloud ERP, some of problems are showed up in the Table 6.2 [32].

Table 3.2: A comparison between traditional ERP and cloud ERP [32]

Factor	Traditional ERP	Cloud ERP
Integration	Depends on vendor	Can be supported centrally
Modules update	High cost	Low cost
Internet	No Need	Needed
IT staff reduction	No reduction	High reduction
Controlling the versions	Complex	Easy
Server cost reduction	Low cost	High cost
Implementation cost	High	Low

3.2.2 Mobile ERP system

In addition, mobile cloud applications are also caught up with ERP systems. Hence, ERP system will be hosted by one of cloud services such as SaaS to support mobility. Figure 3.1 shows a mobile ERP system components [33].

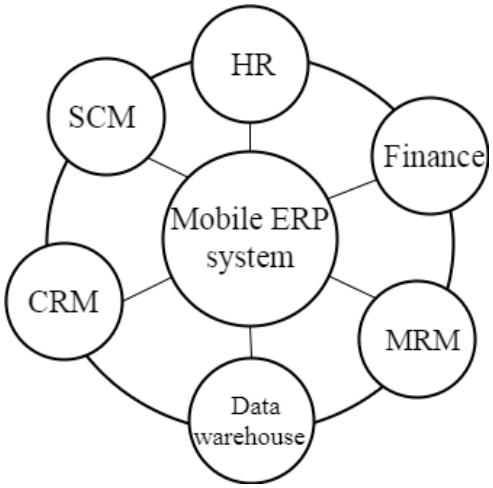

Figure 3.1: Mobile ERP system components [33]

3.3 Business ERP system modules vs. university ERP system modules.

To present the difference between the traditional or business ERP system modules and the universities' ERP system modules see Figure 3.2 [27] and Figure 3.3 [9], the reason of these differences is a circumstance and uniqueness of universities' processes [9].

For more detailed information about the difference between modules see Table 3.3 [11] that

summarize the difference of business ERP functional modules and university academic ERP System functional modules are summarized.

Figure 3.2: Business ERP system [27]

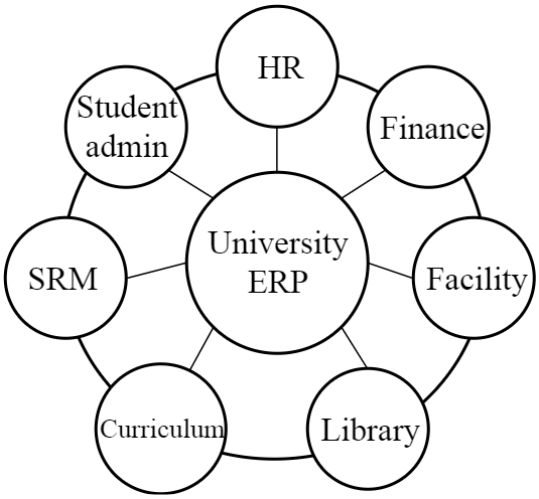

Figure 3.3: University ERP systems [9]

3.4 Business ERP system architecture vs. university ERPsystem architecture

ERP systems are designed to manage all business processes and operations with the best practices in single unified software instead of the fragmented systems across the organization. Also, ERP offers the ability to share applications and the database between users.

The idea of ERP system relies on the central database so, the data across departments, which is stored in the database, can be shared between users and departments easily. Besides, updated data and accurate data are also available. The application was built on the database by software provider; this application includes organization's best practices and involved selected modules and needed packages. Also, the application has a graphical user interface (GUI) whereby the user can interact with the application, sharing information, and access easily to the database. Not necessary GUI is similar for each user, rather it can be modified for each user or user group as their roles in the organization [34].

These roles will give to the user the ability to access and operate a set of different functions and modules according to their work. Basic ERP infrastructure is shown in Figure 3.4 [34].

Figure 3.4: Basic ERP infrastructure [34]

Table 3.3: Business and university ERP functional modules [11]

Traditional business ERP functional modules	Academic ERP System functional modules
Operations modules: helps companies, especially those whose business in the manufacture, to control production processes, particularly in the production planning, implementation, and manufacturing, and manufacturing cooperation	Student life-cycle development modules: This module responsible for supporting student lifecycle processes, such as student' recruitment, admissions, records, and management graduates
Human Resources module: HR module includes operational and strategic functions of human resources. 1. Operational functions involve the database of employees, and salaries management, and employee attendance. 2. Strategic functions involve the development of staff career and training.	Academic services module: contains functions that manage the academic processes across the university or academic institutions, for example, scheduling of the classes, academic structure, content control, and development.
Finance & Accounting (F&A): Is a most common modules ERP system. F&A module is responsible to manage the activities that related to finance in all organization's departments and branches. And gathers data from departments and branches till use it to generate many financial reports such as quarterly statements, general ledger. . . etc.	Student services module: contains functions to help students during their academic processes, for example: enrolment, student guidance, and e-learning.
Sales & distribution module: This module manages the functions of the company's sales, such as the orders place and scheduling, billing and shipping. This module ERP protects a database of products and customers	Enterprise management module: contains functions for supporting the educational institutions' development. For example, HR management financial management, operations support, management of institutions' university's relations, and analytics.
Procurement module: This module manages the companies' procurement process, order, reports, warehouse, and requirements to ensure an adequate supply of product.	

Researchers determined more specific architectures as three-tier client/server architecture, it consists of three layers [11]:

1. Storage logic: that is responsible for data retrieval and data storage request which is coming from processing logic layer.
2. Processing logic: that is responsible of supporting and containing the implementation of business processing, logic, rules, management, and the user authentications.
3. Presentation logic: it is user interface, where the users interact. Figure 3.5 shows the architecture.

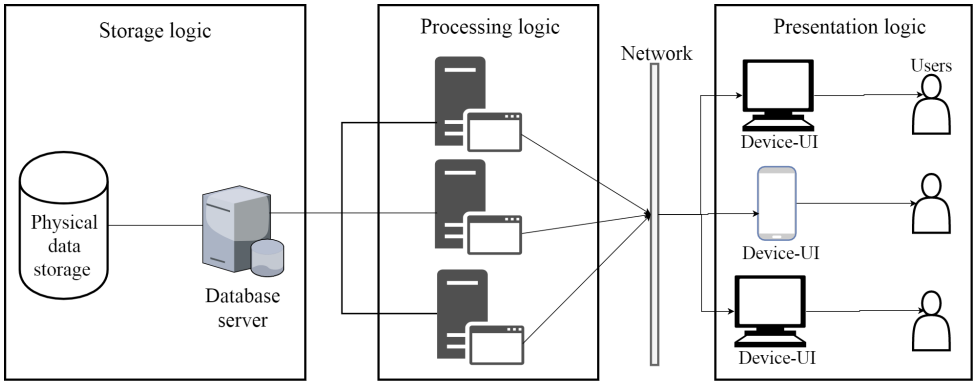

Figure 3.5: Three-tiers ERP system architecture [11]

In fact, we can't employ the traditional ERP system for universities because it is specified to business trend. So, some of changes and transitions must be done because of the difference of activities between two environments; business and university.

3.4.1 Data types between business ERP system vs. university ERP system

In the study of [11], it was mentioned that the data in the database is different between traditional ERP systems and the academic. In general, three types of data in a university ERP system are shown in Table 3.4

Table 3.4: Data types in a university ERP system [11]

Organizational data	Master data	Transaction data
Institution data	Courses	Course enrolment
School/faculty data	Asset	Payment
School major data	Laboratories	Academic evaluation
	Employee	
	Students	

In contrast of business ERP system, the data type in database is different as shown in Table 3.5 [11].

Table 3.5: Data types in a university ERP system [11]

Organizational data	Master data	Transaction data
Enterprise data	Raw materials	Purchase
Companies/branches data	Semi finished goods	Payment
Factory data	Finished goods	Performance report
	Trading goods	
	Services	
	Employee	
	Customer	

3.4.2 Business ERP value chain architecture vs. university ERP value chain architecture

Although this section is not in technical field, but it is worth distinguishing between the differences of business and academic value chain in order to be familiar with all aspects of differences. Porter's value chain approach divided the value chain in two parts of activities supporting activity and primary activity after studying them we concluded that business and academic activities are partially similar in supporting activity part, such as human resources and technology development, but clearly different in primary activity part which is shown in Figure 3.6 and Figure 3.7 [11].

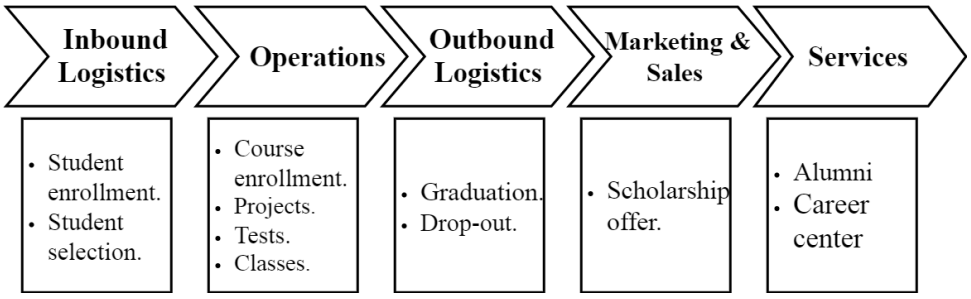

Figure 3.6: Primary activity of Porter's value chain for academic institution [11]

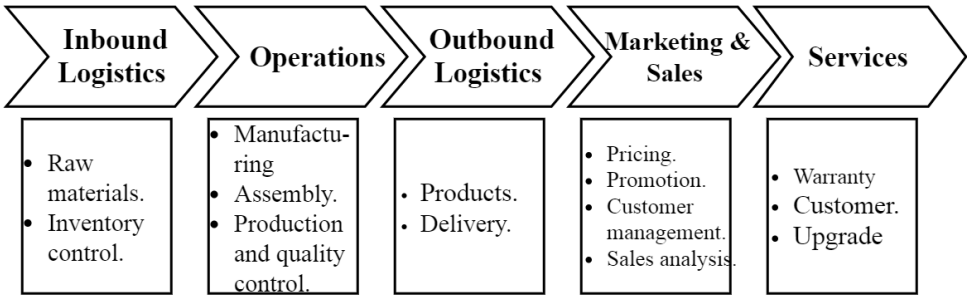

Figure 3.7: Primary activity of Porter's value chain for business enterprise [11]

3.5 ERP system advantages

Companies around the world are interested to implement ERP systems in order to get the best practice and increase efficiency. Also, the ERP applications guarantee that information will be seamless flow inside the organizations [31]. A number of advantages can't be measured after a long period of time since the initial implementation of ERP applications [27].

3.5.1 Business ERP advantages

Five ERP benefits dimensions: operational benefits, managerial benefits, strategic benefits, IT infrastructure benefits, and organizational benefits [35] . The major advantage of adoption ERP system is the integration of data [27] but improving the availability, performance, accuracy of data, efficiency, clarity, and error reduction are also benefits that ERP offers to the organizations [31].The main advantages of ERP systems are listed below [36]:

- Increase the user satisfaction.
- Eliminating the data and procedures redundancy.
- Support daily activates.

- Support decision making.
- Remove the blocks between organization departments.
- Process automation.
- Competitive advantage will improve.

3.5.2 University ERP advantages

In the context of universities, the benefits are divided into two categories business benefits and technical benefits, as shown in the Table 3.6 [10].

Table 3.6: University ERP advantages [10]

Business benefits	Technical benefits
System integration across the campus.	Remove a shadow system.
Improvement of internal communications.	Enable higher validity, data integrity, and reliability.
Remove manual procedures.	Improve data consistently.
Support decision making, planning abilities, and data analysis.	Support user-friendly administrative, student support services, and accessible.
Employee, faculty, and student self-service environment.	Re-engineering business process.
Increase administrative systems availabilities.	Increase security.
Workflow integration, process atomization.	Real-time data access.
	Increase data integration between technology and education.

3.6 ERP system disadvantages

Although ERP systems have a pool of advantages on the organizations that use them, the adoption of this system also have some problems. The implementation cost is high [27] and ERP system is considered one of the technologies that consume millions and billions of dollars according to the size of the organization [37]. In term of best practices of using the ERP system the organization should be ready to re-engineer some of the business processes [38]. So when organization or university want to adopt an ERP system they are forced to replace some old

business practices to a new procedure in order to ensure to get a maximum fit and gain a best practice of ERP. In fact, fit functionality or business process is one of the two approaches of Business process re-engineering (BPR) which the organizations made to implement ERP system. The second approach is customizations of the ERP software packages to fit the business process [19]. The companies must be aware that the complex customizations also may lead to failure [38].

Another disadvantage is employees' resistance, and changing their responsibilities will cause some threats because the ERP system will replace manual procedures and they will nominate to lose their jobs by downsizing [27]. In addition, the implementation duration, data migration difficulties, take a long time to measure the return on investment, high chance to meet the failure is also disadvantages [36].

3.7 ERP system risks and challenges

ERP system implementation processes take a long time to complete, so the risks that threats and possibility of failure of the project must be taken into consideration. Risk can be defined as a problem that has not happened so far, but when it happens it can cause a loss and threaten of the success of your project. Six risk categories and their factors that associated with ERP systems' projects are listed uniquely to these projects as shown in Table 3.7 [39].

Later in 2005, Sumner organized an ERP project risks in four categories which they are more specific and unique to ERP systems: technology, people, project size, and organization.

The technology risks, are different according to how the new system proportion with the existing IT infrastructures and operating system of organization. When the organization decide to implement a new technology, but it does not fit into their current IT infrastructure such as operating system, network, and database that will force the organization to make essential changes in their IT infrastructure. And these modifications on the IT infrastructure increase the risk of technology and may lead to inconsistency of the company's internal expertise with the new infrastructure. To maintain technology risks low, the ERP system technical requirements should be selected with consistency by company's technical infrastructure knowledge. In spite of

efforts to decrease these risks, often technological risks happen when new ERP software package is implemented, more specific when trying to build bridges with old applications. These create lack of integration risks. So the technical issues should be well studied and taken into account when selecting or implementing a new ERP software package to avoid unnecessary exposure technology risks [27].

Table 3.7: Risks categories and factors that are unique to ERP projects [39]

Risk Category	Risk factors unique to ERP
Organizational fit	1. Failure of redesigning the business processes of the organization. 2. Failure to follow the design of the enterprise that supports the data integrity level.
Skill mix	1. Insufficient training, re-skilling, and internal expertise. 2. A shortage of business analysts and technological knowledge. 3. Failure of effectively mixing between internal and external expertise.
Management structure and strategy	None
Software systems design	1. Lack of commitment to unified specifications that support software. 2. Reduction of integration.
User involvement and training	None
Technology planning/integration	1. Trying to build bridges to legacy applications

People risks, if IT professionals in the company are familiar and versed with the ERP

application packages, then the prospect of implementation success will increase. Inadequate training and refine the staff skilling and unsuccessful mixing between internal and external expertise increase the risk of failure. People risk factor is also including the knowledge of ERP employees and how much they are involved in the project. Poor training, ineffective communication, and the lack of sensitivity of the resistance of the user all reducing the probability of success. Risk of failure rises significantly if the users are not interested to do and complete their jobs by fully using the ERP application [27].

Project size risk, ERP system considered a large system that gives a big investment in technology companies for many organizations, the big size of the project represents a significant risk. Any sheer size and important project needs to be supported by a senior management, effective communication, and structure controlling management in order to achieve success [27].

Organizational risks and business process, when the characteristics of the ERP software don't fit the business needs and requirements there are two strategies can be used to treat with these issues. The first one is the redesigning business processes to fit the software. The second one is to modify the software to fit business processes or system customization. Re-designing the business process will decrease errors and increases of exploiting of latest updates of the system.

On the other hand, changing business processes to fit the system means changes in methods of doing business, which may lead to employee resistance and loss of competitive advantages. System customization means that modification will occur in the software that means the cost of implementation will increase, affect the system's stability, and make future versions management more difficult. Moreover, customizing the system involves the least of regulatory organizational changes. Hence, the successful implementation of ERP must have fewer software modifications [34]. After a comprehensive studying of ERP risks and challenges, become clear that, the risks which force the business ERP not much differ than the risks which university ERP face.

3.8 Chapter summary

This chapter clarifies the ERP system evolutions and presents the differences between business ERP system vs. university ERP system. These differences includes: definitions,

structures, data types, modules, advantages. In addition, explains the disadvantages of ERP system and covers the ERP risks and challenges.

Chapter 4

Literature Review

This chapter contains a summary and a literature review of some important contributions related to our work. The chapter includes ERP system implementation topics, practices, activities, and a software engineering perspective regarding developing systems. The second section is concerned with ERP implementation strategies, while the earlier work is related to implementing ERP and university ERP system. The last section explains a critical success factor in addition to special university success factors.

4.1 Software engineering roles in ERP implementation

A well-planned implementation is essential and needed to ensure the feasible development and the success of the ERP system [22]. The approach of how the implementation processes will be done is one of the key factors that affect a successful system implementation [18]. Hence, software engineering (software process) has an important role for the implementation of the ERP system. The software process is defined as a series of activities that lead to the output of the software product. Four basic activities are common to all software development operations. These activities consist of the following [17] :

1. Specifications: include specification of the software, which is to be implemented and the qualifications on their processes.

2. Development: includes designing and coding the software.

3. Validation: includes testing the software to make sure that it meets the customers' requirements.

4. Evolution: includes software modifications to fit in with the changes of the customer and the market need.

The software processes are a mixed series of technical and collaborative activities, in addition to management with the general goal of identifying, designing, implementing and testing the software system. Also, software developers use a lot of different tools to support their software work. Tools are especially valuable to support the liberalization of different types of documents and to manage the vast amount of detailed data and information that is produced in the large project of the software.

Therefore, there are four basic activities of software processes: specification activities, development activities, validation activities, and evolution activities. These activities are organized differently according to the model that is used during the software development. For example, in the waterfall model activities are organized sequentially [17]. Thus, these activities will be executed depending on the type of software, people, and organizational structures [17]. There are different software process models [17]:

1. Waterfall model includes the basic activities of the system specification, system development, system validation, and system evolution. Also, these processes appear as separated phases. For example: phase of requirements specifications, phase of designing the software, implementation... etc.

2. Incremental development model: the approach includes interleaves of specification, development, and validation as activities. The systems have been developed as a sequence of increments (versions), with each increment adding new functionalities to the previous increment.

3. Reuse-oriented software engineering: this approach includes an important number of reusable components which already exist. This process focuses on the development of system integration of these components in the system rather than develop them from scratch. Actually, code, methods, classes, libraries, and even whole systems from the previous implemented system are reused; the reuse has a lot of advantages such as low cost and risk, and implementation process will be faster.

ERP systems are a complicated application; therefore, an implementation may take years for big organizations. The larger the company the higher the implementation cost will be. Although information technology has huge advantages in the implementation of ERP, it affects how a business company runs its processes. Thus, the implementation of ERP system will change how the organizations do business, and their employees must change the way that they do their work. Also, organizations focus on the technical aspects of building a good IT infrastructure. Several types of research develop conceptual frameworks and models in order to understand the processes of the ERP life cycle.

4.2 ERP implementation strategies

It is important to consider how to deal with ERP development projects, what must be done to make it possible while considering ERP implementation strategies, methods, techniques, and the differences between approaches. According to the literature [14, 20–22] there are five ERP implementation strategies:

1. Comprehensive (full customization): full customization of the ERP system to the organizations' business processes. This strategy is costly, requires long time to implement, and needs a high level of BPR.

2. Middle of the road (modifying): the goal of this strategy is to make a modification on some parts of the ERP modules in order to fit the company. Also, this strategy may need business process re-engineering. Middle of the road strategy is less expensive than the comprehensive strategy.

3. Vanilla (minimal customization): In this strategy, there are no required modifications of the system. The organization aligns its business processes to the processes, which are included in the ERP system. This strategy is less costly, so it requires less implementation time.

4. Big Bang implementation strategy: It is when an organization or a company replaces the current system (old) with a new enterprise resource planning system in order to reap its full benefits. All different ERP applications are replaced at different locations within the company while eliminating the necessity for interfaces between the old and new system. The big bang advantages include: short implementation time, high motivation, and completed training before the installation. The disadvantage is in the high risk involved, since the organization is replacing the existing system with a whole new integrated system, which is a risk factor when the system fails, failure in one part may affect others.

5. Step-by-Step implementation strategy: the implementation will be divided into small parts and stages, where new interfaces will be built between old and new systems, thus there is a lower chance of failure and less risk.

On the other hand, the study of [13], has developed a framework for Campus ERP implementation; the study was in Malaysian higher education institutions and is focused on selecting ERP modules. The framework consists of four stages: project initiation, project preparation, realization, operation and maintenance, where each stage includes a collection of CSFs deliverables and user responsibilities.

4.3 ERP systems implementation frameworks

A lot of studies and researchers examined the ERP implementation whether in traditional ERP system or in a university ERP system; all these studies have one main goal, which is to achieve a successful ERP system implementation.

4.3.1 General ERP implementation models

The general ERP implementation processes that consist of three main stages: pre-implementation strategy, implementation strategy, and post-implementation strategy. As shown in Figure 4.1 [34] depicts .

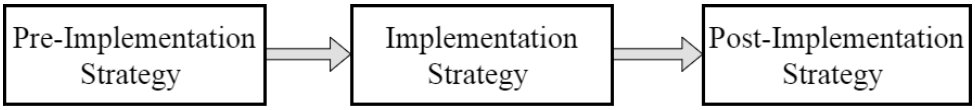

Figure 4.1: ERP systems' implementation stages [34]

4.3.2 University ERP implementation framework

The study of [13], has developed a framework for Campus ERP implementation; the study was in Malaysian higher education institutions and is focused on selecting ERP modules. The framework consists of four stages: project initiation, project preparation, realization, and operation and maintenance where each stage includes a collection of CSFs deliverables and user responsibilities. As shown in the following Figures.

1. Pre-implementation phase

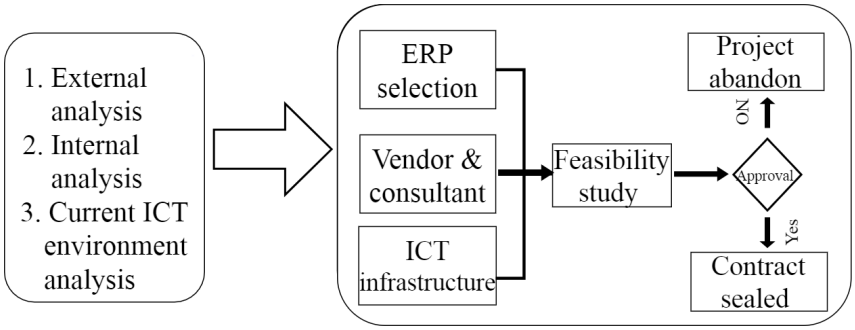

Figure 4.2: Campus ERP framework: project initiation phase [13]

2. During implementation

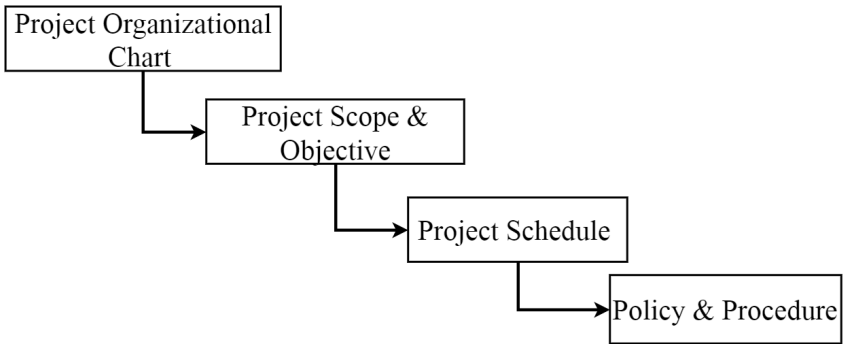

Figure 4.3: Campus ERP framework: project preparation phase [13]

3. During implementation

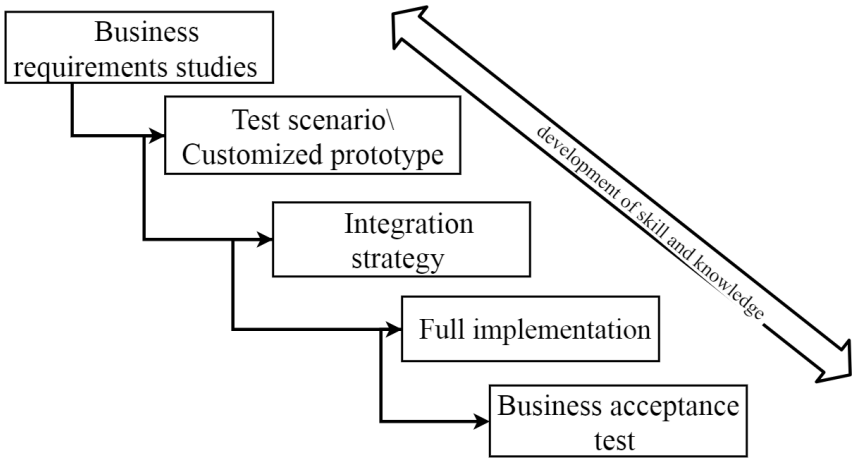

Figure 4.4: Campus ERP framework: realization phase [13]

4. Post-implementation

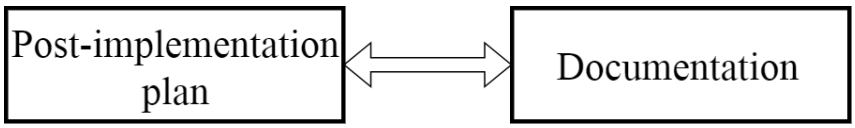

Figure 4.5: Campus ERP framework: operation and maintenance phase [13]

According to the previous framework's figures each stage has a set of internal activities: Project initiation: analyze business environment, internal analysis, external analysis, current ICT environment analysis, and selection process. Project Preparation: scope and objective of the project, project schedule, project organizational chart, policy and procedure. Realization: business requirement studies, test scenario / customized prototype, integration strategy, conversion plan,

developing skill and knowledge, full implementation, and business acceptance test. Operation and Maintenance: establish post implementation plan and documentation. Moreover, ERP implementations through the buying of full packages from SAP as an example has five different stages [40], shown in Figure 4.6.

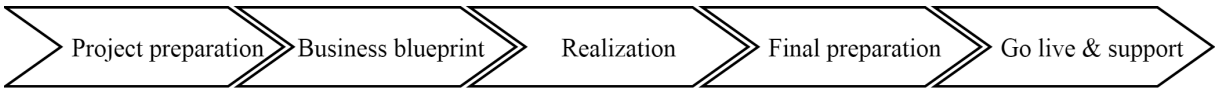

Figure 4.6: SAP implementation processes [40]

The Figure 4.6 consists of [41]:

- Project preparation: involves planning and preparation for the SAP project. This phase is the initial first step, which focuses on primary areas such as objectives, planning, scope, and team.
- Business blueprint: determines the company requirements, which are detailed as a document, and clarifies the scope of the team to focus on the SAP processes.
- Realization: implements the requirements according to the blueprint.
- Final preparation: completes the previous stages of preparation to go live. In addition to testing, training.
- Go live and support: finishes the productive processes and support. Also, monitors and improves the system performance.

4.4 ERP system risks during implementation phases

Risk can be defined as a problem that has not happened so far, but when it happens it can cause a loss and threaten of the success of a project. Risk factors that face ERP system projects during the implementation phases and how to deal with them are shown in Table 4.1 [39].

Table 4.1: Risks factors that force ERP system projects during implementations phases [39]

Project phase	Responsibility	Risk factor to be addressed
Planning	- User management - IT management	1. A shortage of top management support. 2. A shortage of an appropriate project management structure. 3. A shortage of a champion .
Requirements analysis	- User management - IT management - Business analysts	1. Failure of redesigning the business processes of the organization 2. Failure to follow the design of the enterprise that supports the data integrity level.
Systems design	- User management - IT management - IT designer	1. A shortage of business analysts. 2. Unsuccessful to follow the design of the enterprise that supports the data integrity level
Systems implementation and maintenance	- IT management	1. Insufficient training, re-skilling, and internal expertise. 2. Failure of effectively mixing between internal and external expertise.
Technology integration, and implementation	- IT management - User management	1. Trying to integrate ERP with legacy applications

Despite existing studies and researches about ERP system implementation process, the core of these processes is in the field of software engineering.

4.5 Critical Success Factors (CSFs)

Critical success factors are defined as a set of activities that need constant attention in order to plan and implement the ERP system [13]. The CSFs is the main topic that ERP literature is focused on, studied, developed, proposed, identified, and analyzed in the approaches and issues of CSFs through case studies [42]. Some studies are concerned with defining a new set of CSFs,

other studies examine one of the CSFs in detail, and others present them according to specific factors such as the region involved. In spite of a pool of studies that were conducted there are no specific CSFs because of the different environments that the organizations have [30]. Few researches highlighted the CSFs that are related to ERP life cycle [42].

CSFs play the requisite role that helps to ensure the successful implementation of ERP systems and management [42]. Many organizations don't care about the importance of CSFs then they face unexpected problems during the ERP life cycle as [43] mentioned that: 90% of ERP systems have underestimated the required budget, 40% of huge software projects failed, and 67% of application's enterprise didn't meet the needs and goals. Hence, the solid knowledge regarding success and failure factors during the implementation stage will advance the building of an ERP system, which supports the operational and strategic advantages [13].

Therefore, ERP success factors are more significant in the higher education sector than in business organizations because of the educational and administrative activities of faculties, staff, and students being more interactive in the ERP system. Furthermore, the failure rate in the implementation of the universities ERP system is higher than failure in the organizations [4]

4.5.1 Critical success factors of ERP system in universities

Despite the differences between organizations and their environments the main category of technical CSFs that will be discussed in this thesis is common for universities and suitable for their circumstances. There are a lot of factors that have been identified in the literature that directly affect and instruct the implementation of the ERP system and have a clear impact on the result of implementation. In this study, the factors which studies focus on are the factors that are associated with having impacts towards universities. According to the study of [7] there are 10 technological CSFs: complexity, minimum customization, data quality, analysis, and conversion, software development, testing, troubleshooting, network reliability, system response time, visibility of the system status, robustness and error prevention, Flexibility and efficiency of use, and user friendliness, help, and documentation.

In the study of [7] they identified the CSFs in a case study of higher education, they organized the factors into categories: organizational, technical, vendor, individual, cultural,

social, political and national. Hence, this thesis is focused on the technological field where the CSFs are:

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. 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.

Also, four categories of CSFs for ERP system in higher education under the four main categories: critical factors, active factors, reactive factors, and inert factors. These categories are classified according their influence on and are impacted by other factors [7].

1. Critical factors: they are having strong impacts other factors factors and strong impact by other. Top Management support, Management of expectations, Business process re-engineering, Culture of resistance within an organization, Vendor and consultant support to users, Project (ERP) team composition, Education and training of users, Cooperation and communication, Users involvement, and Systems changes and upgrade
2. Active factor: they are having an impact on other factors while less affected by other factors. Change management, Organization politics and characteristics, Interest groups, Management style and decision making, National and organization cultures, and Rules and practices.

3. Reactive factors: they are having a little influence on the other factors when compared with others to them. Flexibility and efficiency of use of ERP, User friendliness of the ERP system, Learnability, User satisfaction, Attitude towards the system, Motivation, and Use of vendors' tools.

4. Inert factors: they are the opposite of active and have less impact comparing with other factors.Complexity, Minimum customization, Data quality, analysis, and conversion, Software development, testing, and troubleshooting, Network Reliability, System response time, Visibility of the system status, Robustness and error prevention, Behavior, Roles, Policies and standards, Norms, Availability of applications, and Political influence.

4.6 Chapter summary

In this chapter, we reviewed some important literature topics related to our work, ERP system implementation topics, practices, activities, and a software engineering perspective regarding developing systems. In addition, we concerned with strategies of ERP system implementation, and showed some models and implementations frameworks. In this thesis (chapter six) will focus on proposing a PPU's ERP framework. So, it was important to study these topic before we go deeper into the case study.

Also, the chapter explained a critical success factors in general and special university success factors. The university CSFs categories are classified according their influence on and are impacted by other factors, critical factors, active factors, reactive factors, and inert factors. So, in this thesis (chapter five) will focus on and explore the technical CSFs which are:

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. 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.

Chapter 5

PPU's Situation Analysis- Case Study

This chapter includes detailed and important information about our study analysis such as methodology, population, sample, study tools, statistical process, and results. Also it describes all the study questions, situations and results.

5.1 Study methodology

We conducted our experiment using case study, which entails studying the current phenomenon as real. We saw that using 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 questionnaires method affirms our understanding of situations and allows us to analyze them critically without any bias to information based on previous experiences of the research [44]. Such methodologies are good when the subjects have previous research done in the same area with the same exploratory frame. Our academic research purpose is descriptive research which aims to describe specific phenomena or events, to collect facts and information about them,

describe their specific circumstances and determine their actual situation. The descriptive research is also concerned about defending the actual situation of the phenomena or the events among the research field depending on certain values or criteria, and suggests the steps or methods that can be followed to reach the image that should be with these criteria or values. It is used to collect data, information, and methods, such as observation, interview, tests, and referenda. Figure 5.1 show the study methodology.

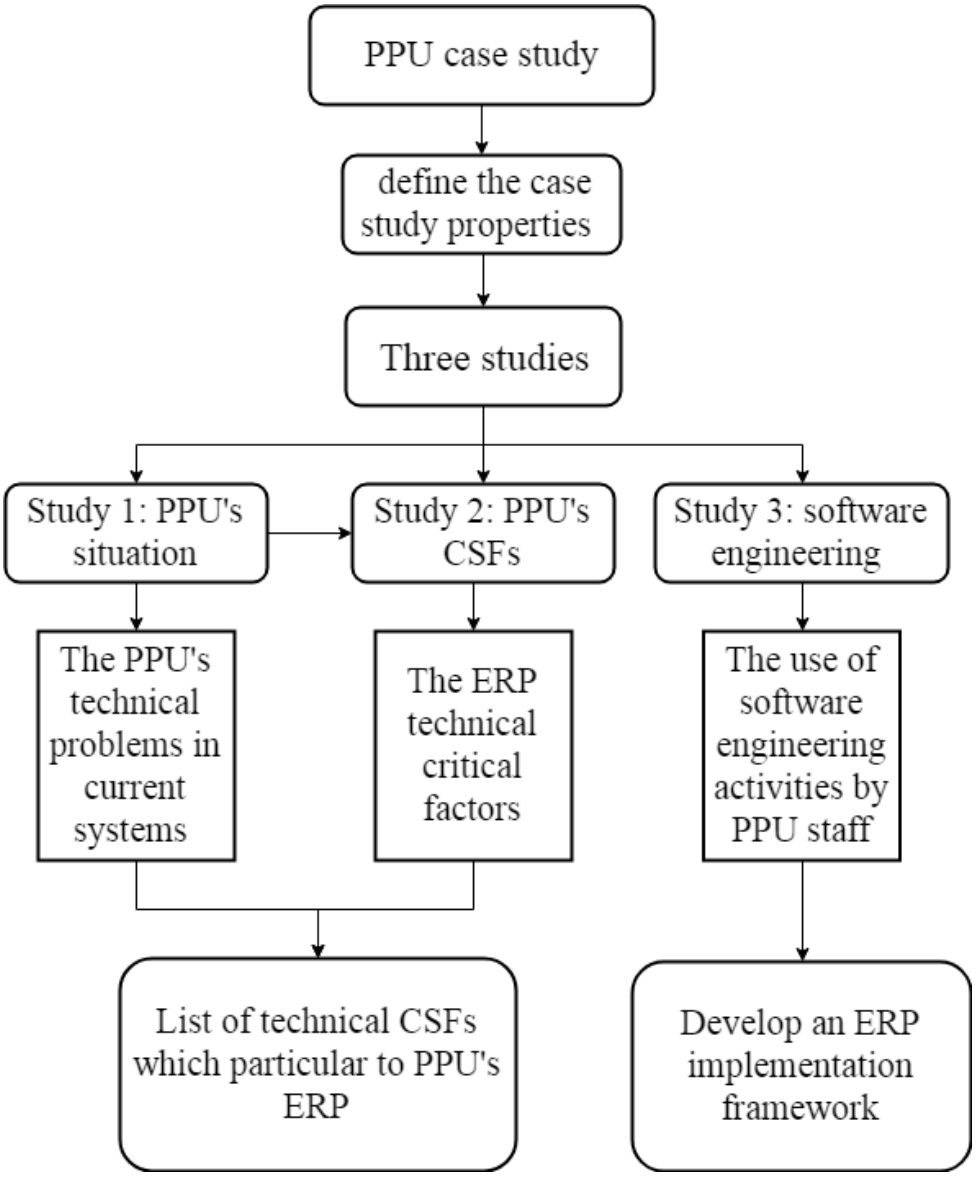

Figure 5.1: The study methodology

5.2 Study design

This research was conducted using three questionnaires in total. The first two aimed to study CSFs. One questionnaire 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 were statistically analyzed and recommendations were extracted. 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.

5.2.1 Population

The population studied was technical people at PPU, who are responsible for developing system inside the university. The technical people properties are mentioned in the Table 5.1

5.2.2 Sample

Consists of (11) technical people who have a significant effect on the development process. Table 5.1 shows the demographic information about the sample.

5.2.3 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%

5.2.4 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.

5.2.5 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 5.1: 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 (IT)	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

5.3 PPU case analysis results

This section includes a statistical analysis of the data generated by the study in order to answer its questions.

5.3.1 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 [7]. 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 5.2
The Figure 5.2 show the results in descending prefer according to the mean. According to results shown in Table 5.2 and Figure 5.2, the factors which were less than 3 must be taken into consideration. They are: menu and documentation, processes workflows, system alert, and data redundancy.

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 [4]. The factor of data redundancy was merged with system

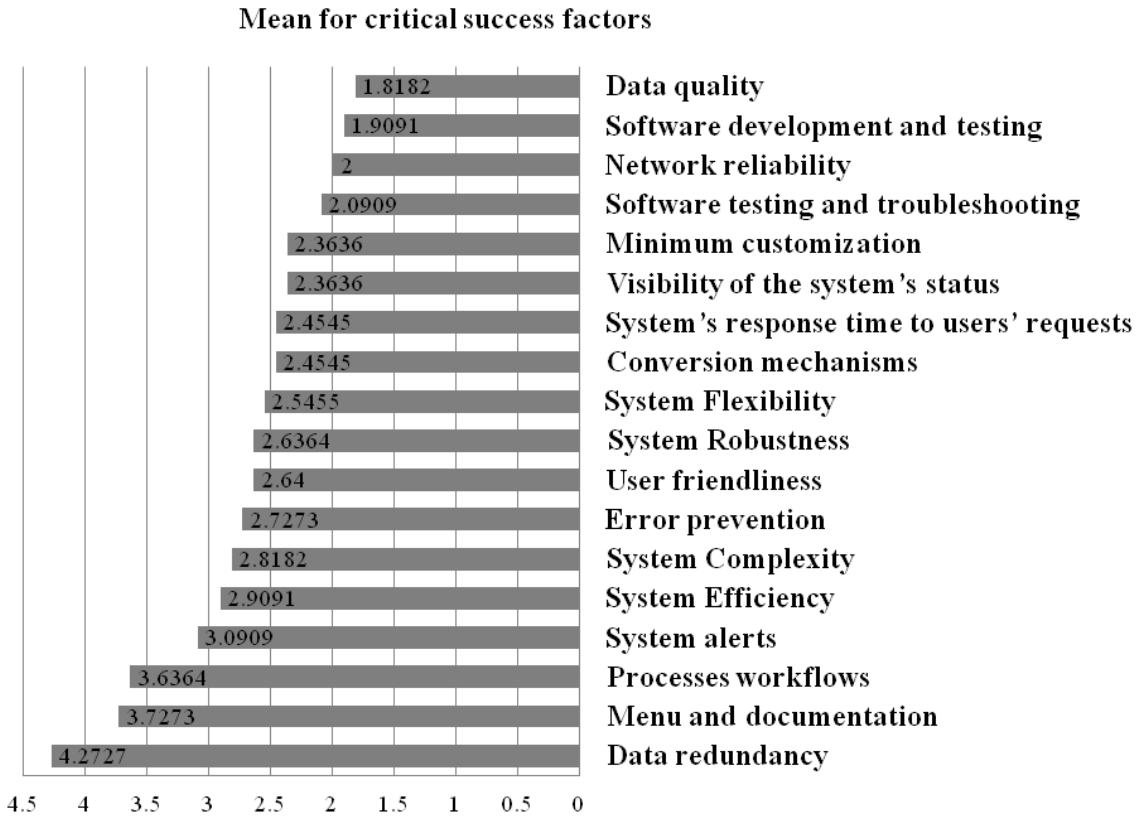

Figure 5.2: Means of CSFs

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). These factors are: 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.

Table 5.2: Means & standard deviation of first study question

	Question	Success Factor	Mean	Std. Deviation
1.	The current systems have not a redundant data.	Data redundancy	4.2727	.64667
2.	Help manuals, and documentations are always provided to user in the current systems.	Menu and documentation	3.7273	1.10371
3.	Processes' workflows in the university are managed correctly.	Processes workflows	3.6364	.92442
4.	The current systems are designed to provide useful and needed alerts	System alerts	3.0909	1.04447
5.	The use of the current system is efficient.	System Efficiency	2.9091	.83121
6.	The current system was designed to be less complex structures.	System Complexity	2.8182	.98165
7.	One of the current systems' characteristics is prevention errors.	Error prevention	2.7273	1.00905
8.	The current system interfaces are designed to be user friendly.	User friendliness	2.64	1.120
9.	One of the current systems' characteristics is robustness.	System Robustness	2.6364	1.12006
10.	The current system was designed to be flexible.	System Flexibility	2.5455	.68755
11.	The current systems have an easy data conversion mechanism.	Conversion mechanisms	2.4545	1.12815
12.	The current system responses to user's requests quickly.	System's response time to users' requests	2.4545	.93420
13.	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
14.	The current systems are highly customized with business processes	Minimum customization	2.3636	.92442
15.	The current systems are tested.	Software testing and troubleshooting	2.0909	.83121
16.	The network in the current system is reliable.	Network reliability	2.0000	.63246
17.	Frequent development and testing are activities that current systems reveal.	Software development and testing	1.9091	.53936
18.	A good data quality is a feature that took under consideration when provided to the current systems' implementation.	Data quality	1.8182	.98165

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 5.3, 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 re-engineering.
10. Applying software engineering standards.
11. Database administrator.
12. Using unified theme of technology.
13. System integration.
14. Training.

5.3.2 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

Table 5.3: Mean & standard deviation of CSFs 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 re-engineering	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

section. Table 5.3 was created which includes the results of the mean and the standard deviation for each technical factor.

The Table 5.4 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 following t-test (According to the statistical specialist we can use the t-test as the sample is almost the whole population) is the used statistic test [4]:

$$t = \frac{\overline{X} - 3}{s/\sqrt{n}}$$

Therefore, according to the questionnaire results which were shown in Table 5.4 and Figure 5.3; the 14 critical and effective CSFs of ERP implementation in PPU, arranged from more critical to less critical are:

1. Security.
2. Training.
3. Data analysis.
4. System integration.

Table 5.4: The t-test value

	Factors	Test Value = 3	
		t-test	p-value
1.	Security	21.000	.000
2.	Training.	12.000	.000
3.	Data analysis	10.757	.000
4.	System integration.	10.757	.000
5.	IT infrastructure	9.690	.000
6.	Database administrator	9.238	.000
7.	Complexity	9.238	.000
8.	Efficiency of Use	9.238	.000
9.	Robustness and error prevention	8.964	.000
10.	Business process reengineering	4.485	.001
11.	Applying software engineering standards	3.194	.010
12.	Using unified theme of technology	3.130	.011
13.	Help menu	2.206	.052
14.	Documentation	2.185	.054

5. IT infrastructure.

6. Database administrator.

7. Complexity.

8. Efficiency of use.

9. Robustness and error prevention.

10. Business process re-engineering.

11. Applying software engineering standards.

12. Using unified theme of technology.

13. Help menu.

14. Documentation

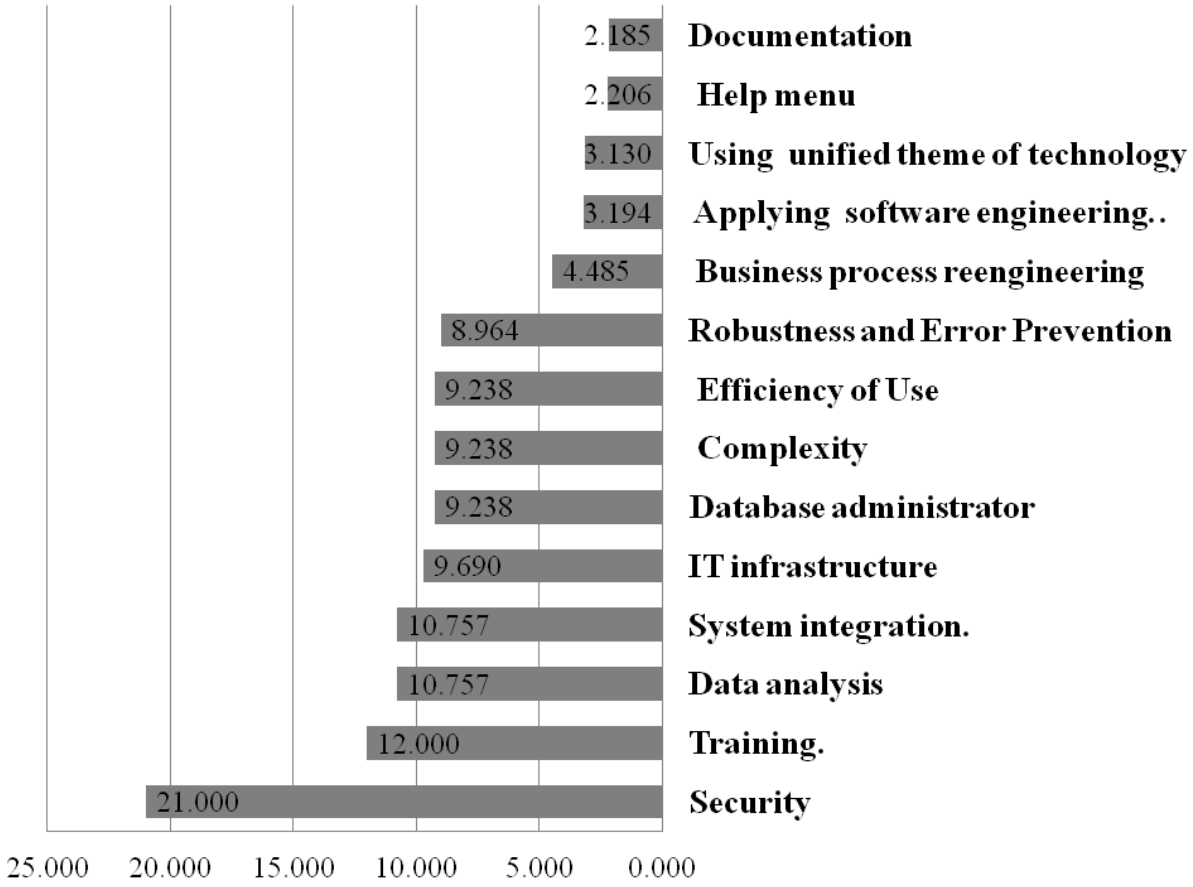

Figure 5.3: Technical critical success factors

5.3.3 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. Theoretical information is extracted from [17]:

1. **Software Specification or Requirements Engineering**

   Requirements engineering activity is the process that is responsible for developing and extracting software requirements. In our research, we studied main sub-activities that must be done during this phase. These include:

   a) Feasibility study.

   b) Perform elicitation and specification of requirements.

   c) Making a scenarios and prototype constructions.

   d) Constructing system models.

The percentage where PPU technical staff applying 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 5.5. 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 [17] elicitation requirements will keep us away from facing problem and errors in the next stages.

Table 5.5: Software specification phase results

Software specification		
	Mean	**Std. Deviation**
Feasibility study.	3.5000	1.26930
Making system models.	2.7273	1.00905
Making a scenarios and prototype constructions	2.7273	1.00905
Making an 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:

a) Applying an architectural design.

b) Applying an interface design.

c) Applying a component design.

d) Applying a database design.

The percentage where PPU technical staff applying 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 5.6. 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 5.6: Software design phase results

Software design		
	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:

a) PPU project developers' team members.

b) PPU technical team members who are well skilled.

c) Availability of technology tools which support the capabilities and productivity.

d) Making system documentations.

e) Conversion plan.

The percentage where PPU technical staff applying this stage was 45.5%. The results of mean and standard deviation for sub-activities included in this phase can be found in Table 6.5. 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 5.7: Software development phase results

Software development		
	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 which support the capabilities and productivity.	2.2727	.46710

4. **Software testing**

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:

a) Test plan

b) Development testing

c) System testing

d) Acceptance testing

The percentage where PPU technical staff applying 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 5.8. 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 5.8: Testing phase results

Testing		
	Mean	**Std. Deviation**
We always have a test plan.	2.8182	.98165
We always do a Development testing	2.8182	.98165
We always do an 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 [23]. 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:

   a) Determine project's activities by milestones.

   b) Frequently sending the project progress reports to the manager by employees.

   c) Setting project schedules (e.g. activity chart, bar chart).

   d) Creating project risk management plan.

   The percentage where PPU technical staff applying this stage was 40.9%. The results of mean and standard deviation for sub-activities included in this phase can be found in Table 5.9.

Table 5.9: Project management phase results

Project management		
	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 a summery, Table 5.10 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 5.10: Total results

Phase	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

5.4 Chapter summary

In this chapter, 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 the existence different data identification and redundancy [23].

This chapter 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 re-engineering.

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 the testing is the least applied.

Chapter 6

Proposed University ERP Framework and Recommended CSFs

This chapter includes a proposed university ERP implementation framework for PPU, with consideration on software engineering practices and CSFs.

6.1 Proposed university ERP framework

There are different structures and approaches that can be used to develop any software application. Each organization's environment differs from others, so each case is considered special. Various methodologies were used in past studies with the aim of improving the probability of ERP systems' success. A successful ERP implementation minimizes the maintenance, production, inventory, and effort in addition to increase the efficiency and the competitive advantages [42]. In proposed PPU framework, there were a series of activities. We tried to combine strategies in the most appropriate way given their current technical situation and environment in order to prepare for implementing the ERP system. PPU ERP framework is shown in Figure 6.1.In fact,

poor planning and loose preparation could cause the system to inevitably collapse [13, 14].

After studying the technical situation and the environment of the PPU in chapter 5, we found that the ERP implementation cases are not considered. Therefore, PPU has to buy some packages such as HR and financial packages and build other modules to fit their needs and special policies because there is no full ERP system that meets local university's needs in addition to the high cost of generic ERP if available. The existence of these implementation cases will help us to show and clarify the needed components, the ERP selection options and how to design, implement, and integrate them to get the full benefits of ERP. Furthermore, many universities were unconvinced about changing their business processes, because the high customization of ERP will cause the implementation to fail.

In our study, the technical staff pointed out the necessity of making some business process changes in order to improve the university workflow. Making these process changes requires experts and consultants with full knowledge on these kinds of systems.

Accordingly, it's worth paying attention for the difference between system installation and system implementation. Whereas installations consider a mechanism or a way that is used to change one system to another with minimizing faced problems as much as possible. Therefore, when a company implements a system it uses a number of methods to obtain their goals by modifying the way they carry out operations with. Thus, during the implementation stage, the software will be used as a tool to ensure the company's operational and strategic goals in addition to the systems' installation. So, a successful system installation will not guarantee which ERP system will ensure to achieve the goals after few years of usage [18].

Therefore, standard system implementation activities which are mentioned in the software engineering books such as [17] deeply explain what must be done during the implementation lifecycle.
Here, we studied PPU practices during the implantation and found that there exist some lack of care and some negligence [23]. We defined the activities, which PPU staff should focus on, in order to try bridging PPU's staff practices and standard practices. In addition, the proposed framework organizes the sequence of operations, which clarifies the activities and

their importance during ERP implementation. ERP is a very complex system in which many considerations and dimensions are involved during the implementation. Therefore studying this framework will inevitably help towards preparing ERP for the university.

On the other hand, activities and phases can be broken down to smaller tasks with iterative method in order to reduce the risks. This thesis explains and describes an ERP implementation framework based on the following:

1. Existing theoretical development activities.
2. University's ERP system methodologies and models.
3. PPU case study.
4. Literature studies of ERP system implementation.

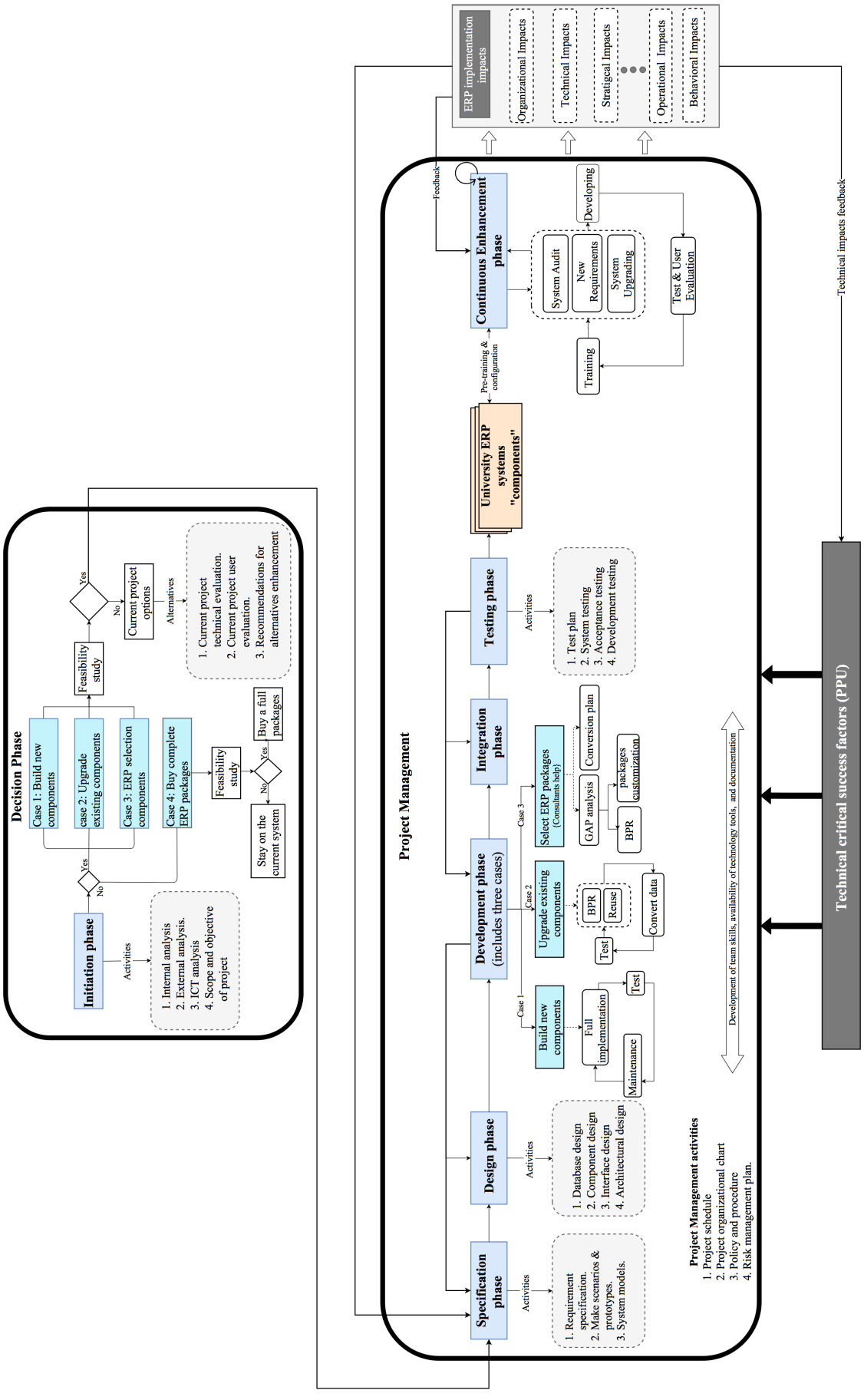

Figure 6.1: PPU's ERP framework

6.1.1 PPU's ERP decision phase

This phase is the most important of the ERP life cycle because PPU studies all the development situation aspects and options in an effective and scientific way. Here the right decision will lead to the right implementation later and the chance of failing will reduce. The effective university plans, goals, visions and justifications are considered as one of the critical success factors [45], so the clear identification of the university's situations and profound analysis of internal and external situations will enable tracking the university's goals. Also, reviewing the university solutions is important to decide what and which system will be suitable for our situation. Additionally, project requirements, goals and objectives, defining clear vision, and a detailed complex project plan should be developed to align with PPU's objectives to ensure the successful implementation of the ERP system [19]. PPU's ERP decision phase is shown in Figure 6.2.

This phase is responsible for making initial steps that help the technical decision makers to decide the ERP solutions that are needed across the university according to the technical situations. This phase is considered the key business decision. It is important to conclude it well in order to prevent problems and risks before the ERP project begins, as well as to determine the IT infrastructure situation, and to choose optimal solutions that PPU needs. This phase involves three parts: the initial phase, the ERP solutions cases, and the feasibility study.

All analysis activities during the decision phase will be done by PPU's members such as management, IT department, faculty members, student affairs department, finance department, human resource department and admin department in cooperation with the consultants and vendors [13].

As the first activity in the ERP project, the initial phase is responsible for studying and analyzing PPU environments, which includes: university's internal environment, external environment, and current PPU's ICT environment analysis. These initial activities will help us to prepare well for our ERP developing cases.

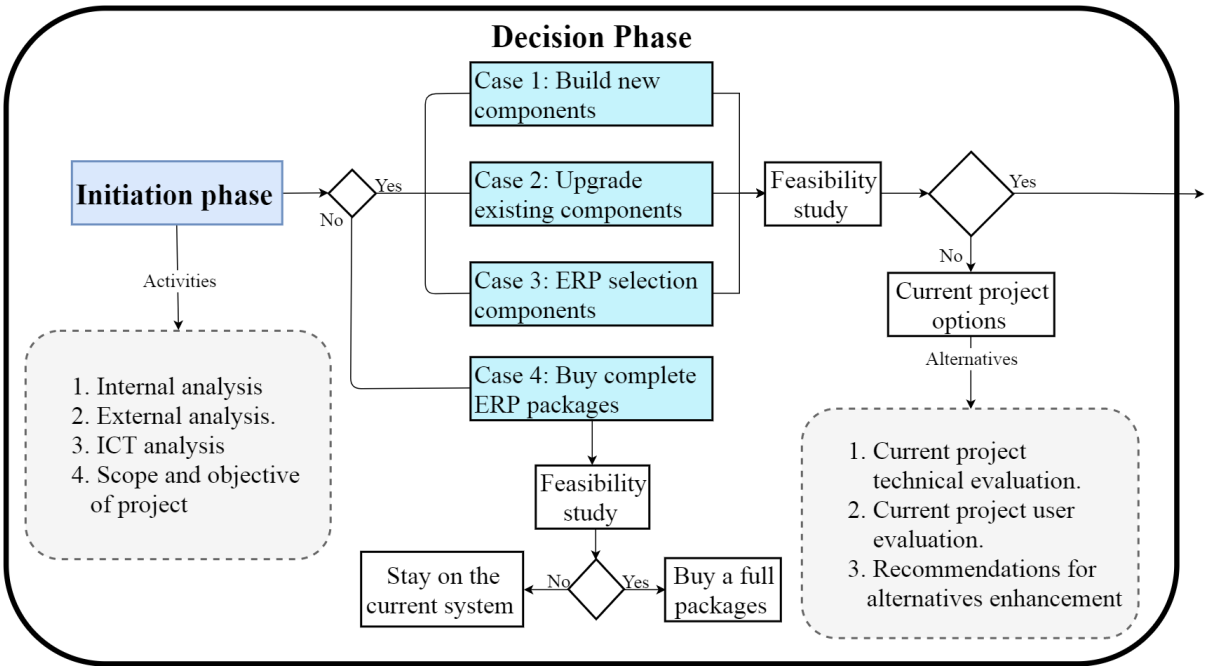

Figure 6.2: PPU's ERP decision phase

These analyses will be completed and executed at all university's processes, whether inside or outside the university, such as university's entity functions and university's issues. Internal analysis is concerned with some aspects of the university, such as faculties and departments. As for external analysis, it is responsible for competitors, vendors, customers, suppliers, etc. In addition, the current ICT analysis is the big challenge for developing new strategies, so the technical and developing situation has to be collected and assessed [13].

These analyses are vital and important for [13, 46]:

1. Explaining, documenting, and analyzing institutional and individual university objectives, strategy, needs, alternatives, scope, and capabilities.
2. Creating a strategic framework that clarifies the university's documents and links it with the objectives.
3. Studying the market, vendors, consultants, IT firms and know the nature of the university's business.
4. Gathering and analyzing the IT infrastructure situation

The understanding of scopes, objective, expectations, alternatives, deliverables, and strategic goals through the organizations is considered a critical success factor in helping to obtain a successful ERP system. The study of [47] indicates that the role of the clear goals and objectives is 30.70% in determining a successful ERP system implementation. So, fitting those aspects is important for the university ERP system to empower decision makers to decide correctly [13, 48]. Also, ERP projects have different physical scopes such as: single sites, multiple sites, and international sites. The number of users may vary among projects as well [49].

In fact, the project plan must be conducted to support and develop the university's vision, because ERP system's investment is closely aligned with the strategic direction of the university, and must be consistent with its vision and future trend. Project plans are considered as a direct link to achievement; "Project plan gives detailed & completed steps on what needs to be achieved in the ERP project" [19].

After carrying out the needed analysis reports, we will move to the ERP solution cases. The main objective of these cases is to decide the most appropriate case for implementing a university ERP system. After the study of PPU environment, we found that there are four cases related to its status:**case one**: build new components that does not exist before, **case two**: upgrade existing components to add new functions and to be able to be integrated later, **case three**: ERP selection components: select needed packages to buy. **Case four**: buy complete ERP packages. This case is related to external vendors while the implementation process is connected with the vendor strategy. Therefore, the university must study this decision by a feasibility study to determine the cost, benefit, and time until having the ability to decide if this way is required or not.

After studying the PPU's situations in chapter 5 and [23], we concluded that the first three cases are needed in PPU, so we will integrate the implementation process between these cases. Also, these cases need a feasibility study in order to analyze and determine all needed information, technologies, and alternatives to the system. Feasibility study aspects are operational, technical, economic, and schedule [13]. The purpose of the feasibility study is to decide if the system development is feasible to develop or not [46]. The Feasibility study assesses whether the users' requirements can be met and satisfied by using the current software system and hardware technologies.

The study is intended to identify if the proposed system will be cost-effective and if it can be developed within existing budget; cheap and fast are two aspects of the feasibility study while the result should indicate if more detailed analysis is needed to continue developing [17]. If the result of this process is approved and can continue in PPU ERP system, then the process will move forward to the next phase, which is the specification phase. If the feasibility study is not approved, then there are current system options and alternatives, system enhancement recommendations, and user and technology re-evaluations are required.

6.1.2 PPU's ERP specification phase

Software specifications and requirements is an engineering activity that is responsible for developing and extracting software requirements. The specifications are designed to communicate the system needs of the users to the system developers [17]. Therefore, at the first, PPU should evaluate its requirements and business needs which lead to implement an ERP system. Deep and detailed specifications of requirements help and guide on how to start the project correctly. PPU's ERP specification phase is shown in Figure 6.3.

Also, it is important to understand and determine the system's services, operation, and constraints. This stage is considered critical because applying it in the correct way will prevent us from making errors later in the design or in development stages [17].

Accordingly, it is highly considered to conduct workshop series as Business Process Requirement Studies including the main application users as academic and non-academic university members, consultants and vendors. This study examines various business processes within the project scope. During this process, they should highlight all issues related to the proposed new ERP system and existing university processes [13]. "Project requirements give a clear view of what requires to be done during the ERP project" [19].

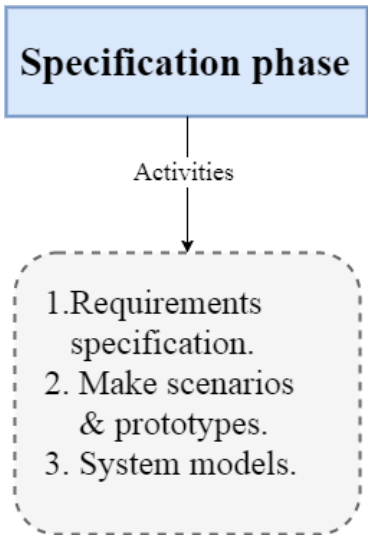

Figure 6.3: PPU's ERP specification phase

We have highlighted the basic and important activities that should apply during this phase and we sorted them in descending order from the lowest applied activity to highest one according to the survey results in the previous section. This will help to take them into account when applying the new ERP system in PPU.

1. Making an elicitation and specification of requirements: This step involves extracting the requirements of the system by observing the existing systems and discussions with customers, buyers, and analysis, etc. Also, the election may involve creating some of the system models to increase the understanding of a system that will be developed. Specification requirements are the activity of translating the information collected during the analysis into a document, which specifies a set of requirements.

2. Making a scenarios and prototype constructions: This is important if requirements are not clear [46]. Also, prototyping makes it easy for the user to understand and follow the processes [50].

3. Making system models: This is possible using the suitable and preferred tools by technical people such as using UML tools.

Generally, the requirements specification is required in all three cases. PPU's technical people and managers are responsible for decisions about what subsystem must start according to their

time plan and milestones of objectives.

6.1.3 PPU's ERP design phase

Software design: This phase describes the structure of the system, which intends to be implemented and indicates the models of data and structures that will be used by the system, interfaces between components of the system, etc. Designers do not finish the final systems' design immediately as it is iteratively process and interleaved with other phases. Therefore, designers add details and aspects, in order to achieve the correct design [17].
Designing new systems' activity is devising the software and implementation procedures for data processing, which contains a detailed specification especially for programmers. It is important to use UML tools to model the system structures, interfaces, and classes. PPU's ERP design phase is shown in Figure 6.4.

We highlighted the basic and important activities that should be applied during this phase and state them in specific order from the lowest applied activity to the highest one according to the survey results in the previous section. These steps help in applying the new ERP system in PPU.

1. Applying database design: Defining and design overall data structure of the system. In addition, it important to determine how data will be shown on the database.

2. Applying component design: Defining each component and function in the system and specifying how to operate them as well as defining changing and reusable existing components by design models.

3. Applying an interface design: Defining the interfaces between system components in the clearest way to give us the ability to know how to design and implement the interface.

4. Applying an architectural design: Identifying all of the system structure, basic components, and their distribution across the system, and relations between them.

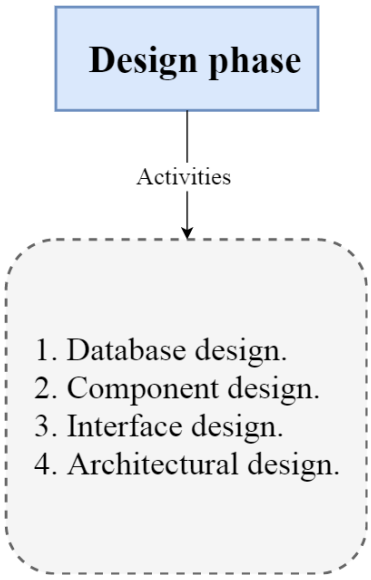

Figure 6.4: PPU's ERP specification phase

Generally, the designing phase should be done for all three cases, and all designing types should be done in a compatible form with the requirements that are specified. PPU's technical people, designers, and managers are responsible for decisions about what subsystem must start with according to their time plan and milestones of objectives.

6.1.4 PPU's ERP development phase

ERP implementation is not only regarded as a technological project, but also considered as an organizational and business project. So choosing a strategy to develop is regarded as a critical factor for success [45] and methodology selection [51]. In fact, [47] indicated the role of the implementation methodology in determining the success of the ERP implementation as 52.20%.

Therefore, the software development stage is the core of development process. It is responsible for converting system requirements and specifications into an executable system during the process of software development. Also, during software implementation the developers need a lot of several tools to support their software work. Hence, in PPU, this phase includes mixed tasks according to the cases that are required in the university installing software, hardware, coding, testing, reusing, data conversion, staffing, documentation, etc. Most of these tasks are made by consultants' advices. PPU's ERP development phase is shown in Figure 6.5.

Tools are especially valuable to support the liberalization of different types of documents and to manage the vast amount of detailed data and information produced in the large project of the software.

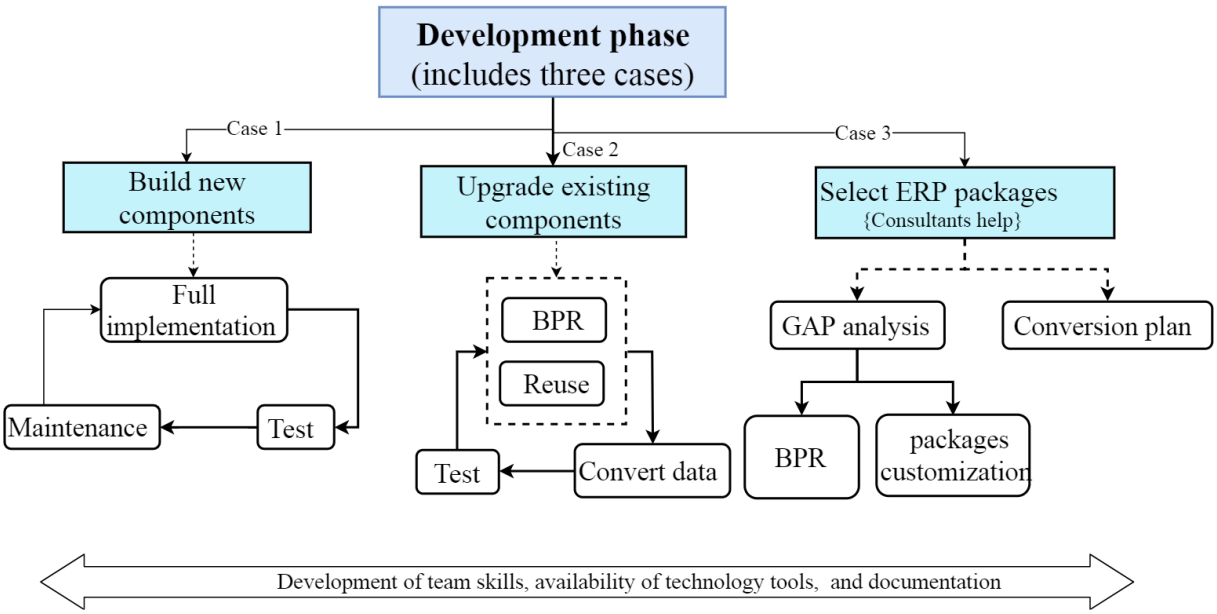

Figure 6.5: PPU's ERP specification phase

We have highlighted the basic and important activities that should be applied during this phase and we are sorting them beginning from the lowest applied activity to the highest one according to the survey results in the previous section, so as to take them into account when applying the new ERP system in the PPU.

1. Availability of technology tools which support capability and productivity. PPU technical team members are well skilled. Technical skills are an important part of the team's functionality, such as PPU structure knowledge, soft skills, and expert and authorized team [52].

2. Conversion plan.

3. Making system documentations.

4. PPU project developers' team members. Skilled and professional team, and able to take decisions quickly and efficiently [45].

Business process re-engineering is vital in this stage where we apply fundamental rethinking and redesign of business processes to improve performance [53].

Data conversion plan is the process to convert data from the old system, upgrade components and select packages to the new system when the data structures between the two systems are different [13]. The objective of data conversion is to satisfy the ERP system rules. Therefore, conversion data stages are: extracting data that exists in the old system, cleansing, formatting, and then installing the new system [13].Data conversion issues can be summarized as data transfer, connection with other systems, and adaptation of software [41].

Case one: build new components

Developing the first case, PPU needs to build the applications that do not exist. In this case, the requirements specification and design activities have been made previously and the decision about what should be coded is done. The project team has a clear vision about what and how it should be done. So, the coding team will fully implement the planned and needed software then perform testing and maintenance as required.

Case two: upgrading existing components

Upgrading the existing systems and components is essential in order to be compatible with new needs and other ERP parts. As known, the system replacement is more complex and difficult than replacing traditional applications [13] so reusing some parts is required and will help to save time and efforts.

There are a lot of software reuse forms such as reusing classes, methods, libraries, and even may reuse the whole application. Reusing concept contains reusing a knowledge and code from the system, which is already implemented. The important reuse advantages decrease the cost and reduce risks. Software development process will be faster and efficient in designing reusable components [17].

However, PPU staff may need to reuse some parts and change some business process to achieve consistency between system and business process. Here BPR is inevitably essential. Then making conversion methodologies is required to transfer data and to link other system parts.

It is important to transfer data from old system to new upgraded system. Besides, testing the upgrading parts is critical to maintain the performance.

Case three: ERP selection

PPU buys ERP packages to reduce time and develop efforts because the activities of coding, testing, and maintenance are not required [46].

On the other hand, the university staff will work to ensure that the selected packages are correct. There are several studies that determine how to select packages, but in general all of them flow in the same sense, which starts with their requirements, analysis, and negotiation with vendor, consultation, some packages modifications and data conversion, to mention few. There are various vendors in the market while choosing a suitable one is very important and is critical. Evaluating the vendors include reputation, capabilities, vision, and financial strength [45]. As for the vendor, the university determined the needed requirements, so it is important to be sure about the vendor's stability in order to ensure the future collaboration [52]. In this case we need:

Consultants help: they play vital and different roles in ERP system implementation. Therefore, consultant must be chosen precisely; because they have a large amount of ERP system knowledge, skills, and capabilities. The ERP system needs a lot of business experience and effective consulting knowledge about investments, vendors, and the recourses [52].Also, the study of [47] indicated that the role of consultants is 35.70% in determining a successful implementation of an ERP system when used. Consultants can assist in staffing the project team, help fill jobs, be responsible for project management, project review, and work as a major contractor [19].

Gap analysis: considered as a negotiation step between university requirements and the packages' functions. It is highly considered to let people with different views and opinions participate in a project to work as a team and to move forward smoothly. It is important to invite outside consultants who can act neutrally to resolve problems and push the project forward by giving guidance instructions. In fact, gap analysis is a required stage during the implementation of the ERP system, where the university tries to detect the gaps between the current business practices of the university and practices that are supported by the ERP package. The gap solutions

can exist in various forms such as identifying a third-party product, design a custom program, and change the source code of the ERP [14]. After deep negotiations, PPU must decide if the packages need customization or functions must be re-engineered.

1. *Package customization:* is necessary for each ERP system, while all previous studies recommended a minimal system customization of standard one, in order to maintain upgrade and to get full system's benefits [52]. Here we need to create a balance between customization cost and optimal business process [52].
2. *Business Process Re-engineering (BPR):* re-designing the university's workflow and processes to realize a radical positive change in performance [46].

A *conversion plan* is needed when the university decided to invalidate the current system and replace it with new selected one. So, conversion plan is important to transfer data from the old canceled system to the newly selected system.

ERP project includes many staff across all departments and colleges. So, the lack of knowledge and skills certainly will affect the level of implementation success and can also contribute to staff resistance. Because of this situation, the organization must implement clear and special programs to ensure the successful implementation of ERP project in the university. Meanwhile, as in the mentioned literature, there is an important need to create a solid, core implementation team, which consists of the university's best and brightest employees, in addition, to successful ERP implementation by the cooperation between technical, business experts and end users. The study of [47] indicated that the role of teamwork is 49.30% in determining a successful implementation of an ERP system. Accordingly, good quality team members will increase the chance of success because they are preparing right and high quality implementation plans, schedules, tasks, and assessments [19]. Otherwise, the team must document all of the system requirements, design, programming, user training manuals, and user acceptance.

6.1.5 PPU's ERP integration phase

The university should completely integrate enterprise resource planning systems into their day-to-day operations in order to realize the full benefits of ERP. Thus, data integration across

university systems is important to ensure the success of an ERP implementation system. However, it has been assumed that organizations should be aware of the potential risks of errors that may occur in this process, as their tight integration will increase the potential errors, which may occur during this process. Therefore, the university should be fully aware of potential faults [19].

The core part of ERP system implementation is the integration. In fact, the system integration will minimize the IT total cost such as maintenance and increase the understanding of the business processes and new integrated system [13]. System integration between existing systems and all three cases -developed in the previous phase- is a major and critical factor leads to success as well as providing a global enterprise vision of information and business processes. These integration strategies are [13]:

1. Ensuring that there is no duplication by improving the ownership and the reusability of the data.
2. Link and merge all modules including student module, finance, human resource, and finance. This ensures end-to-end business.
3. Serve new requirements from financial and academic systems. Therefore, we have to modify and upgrade the existing one, and make the structure of the existing database available for any new modifications.
4. Provide integration within the database view in order to have a single-sign on.

Some of the activities have to be done in this stage to ensure the completeness of integration [13]:

1. Ensure that physical and technological infrastructure and application process is complete.
2. Take care of all issues that were addressed during the development phase.
3. Test all documents and modifications.
4. Availability of vendor and consultants for the day of integration.
5. System integration testing.

6.1.6 PPU's ERP testing phase

Testing is considered as a real validation and verification processes of any software. So, software validation is the process of verifying that the system complies with its specifications and meets the real needs of system users [17]. So the system and data have to be audited before the final setup [54].PPU's ERP testing phase is shown in Figure 6.6.

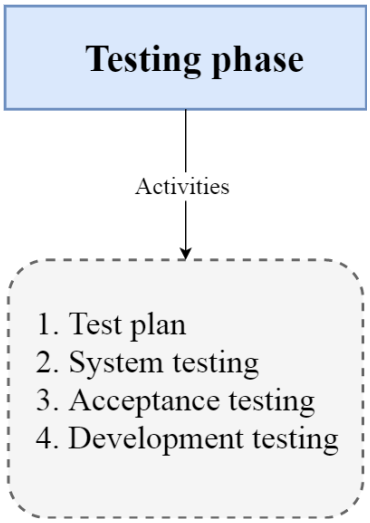

Figure 6.6: PPU's ERP testing phase

We have highlighted the basic and important activities that should apply during this phase and we are sorting them from the lowest applied activity to the highest one according to the survey results in the previous section to consider them when applying the new ERP system in PPU.

1. Having a test plan.

2. Doing system testing: developers always concern to find components and interface errors and problems that appear from unanticipated interactions. In this phase, developers check to see if the system meets the functional and non-functional requirements and be sure to have right integration [13].

3. Doing an acceptance testing: a final activity of testing stage concerns with testing the system by using real data rather than simulated data.

4. Doing a development testing: developers make a unit and component testing on each component independently.

ERP system verifications are important in order to ensure that the system works technically and that business operations and process configurations are practical. Also, when business processes are installed and executed, it is important to test if the university's processes described in the application actually match the processes taking place in the university [55].

After the testing phase for all integrated packages, which are selected, built, and upgraded, is done, we then can announce the first release of PPU's ERP systems components.

6.1.7 PPU's ERP project management

All systems should be developed using the studied, understandable, and managed development process. University must plan the development process and must have a clear and complete ideas about what will be developed, what is the outcome of the development process and when it will be completed [17]. Project management is using the skills and knowledge in coordinating the project schedules and to monitor the project activities to ensure achieving the objectives [4]. In fact, we considered project management in our framework as a continuous phase that began before the technical phases started. Literature studies mentioned that project management is a critical success factor because of the ERP system complexity and the required activities planning, monitoring, and coordination in different stages especially implementation phase [45].

Organizations, which want to adopt ERP while having a shortage in the reorganization strategy, may face technical and administrative problems, and may face delays in ERP project implementation or even full failure of implementing [2]. Also, in the study of [47]indicated the role of project management to be 44.70% in determining the success of the ERP implementation.

We have highlighted the basic and important activities that should apply during this phase. We sort them starting from the lowest applied activity to the highest one according to the survey results as of the previous section, to take them into account when applying the new ERP system in PPU.

1. Frequently sending the project progress reports to the manager by employees.
2. Determining the project's activities by milestones.
3. Creating a project risk management plan.
4. Setting Project schedules (e.g. activity chart, bar chart). This activity is considered the key part of all management work, because it determines what, when, and how to do activities, in addition to project progress, control of overall activities, resource distribution, delay, and achievement of expected goals [13]. Furthermore, schedule flexibility is necessary to help achieving success [52].

Generally, to get an effective and complete ERP project management, many dimensions must be taken into account including the project structure and decision-making authority, clear ERP project objectives, the project responsibilities, and the resource management [52]. In addition, risk management methodologies must be considered [41]. Also, setting project plan, schedule, quality, and budget are significant factors. One of the failure causes is that managers do not devote their effort and time as required [13]. The concept of change management refers to the need for the implementation team to make a formal change in the management strategy and the necessity to consider the implications of such projects [13].
Change management deals with continuing assessments and modifications of personal and organization's behavior. Change management reflects more efficient organizational agility and efficiency [56].

In addition to the project management, [24] classified managements to consist of four types of management roles according to the critical success factors: top management role, technology management role, process management role, and change management role. Which are concluded in Table 6.1 [24].

6.1.8 PPU's ERP continuous enhancement phase

ERP life cycle: broad management and assistance or support is a continuous concern instead of being an objective aim. The pre-implementation, implementation, and post-implementation phases carry on throughout the lifespan of the ERP as it develops and progresses within the

Table 6.1: Management roles [24]

Top management	Technology management	Process management	Change management	Project management
System and packages versions	System configuration	System customization	User involvement	Project Evaluations
Project vision and goals	Hardware and software issues	Packages vendors	Manage the organization cultures	Team selection
Implementation strategy	Monitoring system and process performance	Communicate with consultants	Training	Staffing
Implementation support	Data accuracy insurance	Standardization	Tasks Commitment	Communication and coordination
Project champion	System testing and troubleshooting		Discipline	Formalization the plan
Decision delegation				Leadership
				Scope implementation management.

organization. This contradicts the traditional aspect of operational information system, which characterizes a system life cycle depending on development, implementation, and maintenance. Hence, the analyses of ERP implementations show that their life cycle includes a huge emphasis. After primary implementation, it is important to go through the following checkups and revisions, re-implementations and enhancements that surpass what is commonly a deliberate system support and maintenance. When the number of organizations practice ERP grows and ERP applications in the organizations grow rapidly, maintenance is indeed needed. A greater comprehension of the ERP life cycle is also helpful in leading the ERP research plan [43].

"Going live" stage is not the end of ERP system implementation; it is a continuous process that adds new operations, functions, modules, and updates the needed changes, which are then carried out over university processes. So, these ongoing changes take place throughout the ERP system's lifetime as it grows in parallel with the university [57].

The objective of post-implementation phase is to identify the maintenance and support activities that university integrated ERP systems need. In this phase, the system will be protected and hence reduce the repair costs [13]. PPU's ERP continuous enhancement phase is shown in Figure 6.7.

This phase includes three options for maintenance, enhancement and system audit. The main objective is to verify which system meets the users' requirements. It is the best way to carry out periodically [13] to keep on-going system extension, repair, and upgrading. Next, we will develop the required parts and test them all. We developed and carried out a user evaluation and training. It is so important for PPU to prepare the follow up plan because the need of these parts is relative to our university's requirements and situations.

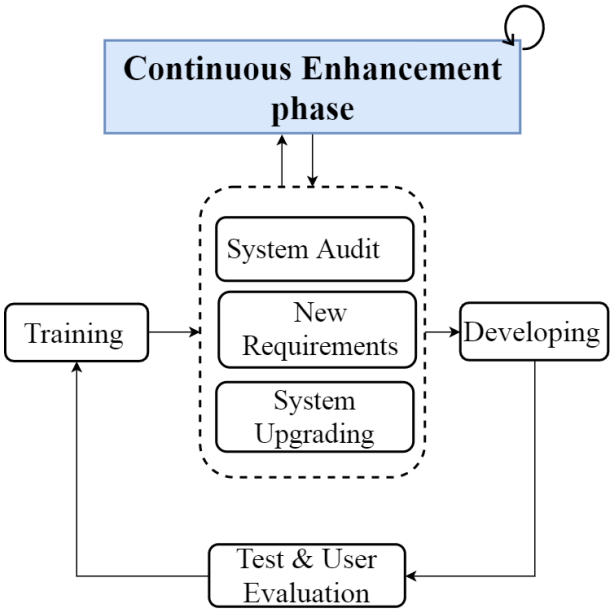

Figure 6.7: PPU's ERP continuous enhancement phase

Overall, *training or education* is considered one of the risks that face ERP system projects because the lack of training will increase the chance of project failure [52]. However, if the training cost is high then it is preferred to make a plan for it [46]. The university should offer the training activities at least twice in order to give the users a time to use, try, and test. Also, the training helps to reduce user system resistance and to change their perception about it [52].

User evaluation is considered important because the project will not be completed without some evaluation activities and probably be difficult to determine the performance measures [19]. The evaluation will help us ensure if the user gets the benefits of ERP in a positive way. Otherwise, enhancement which is also called the maintenance phase, is considered to be one of the longest phases since performing changes and evolutions are required over time. Therefore, the university policies may change, which includes: university strategies, used technology, and environment.

Therefore, adding, upgrading, or expanding processes must handle such changes. PPU should employ a support team for system's enhancement, maintenance, and training. Otherwise, retention of the employee is one of the biggest challenges especially those with experience in ERP implementation. Therefore, the university has to create a program to retain the proper employees to get full benefits of university investment in manpower and support [13].

6.1.9 PPU's post ERP system implementation feedbacks

The ERP system is a multi-dimensional system that affects organizations' performance on more than one level. So, after an efficient use of ERP system of more than one year, the university must get positive impacts on many dimensions such as organizational impacts, operational impacts technological impacts, behavioral impacts, etc. The impact is positive when CSFs are applied in the right way, hence it means that ERP is successful and its users are satisfied as shown in Figure 6.8.

So, there are three feedbacks added into our framework, which are required in order to enhance, follow up, apply evaluation, and prepare troubleshooting for PPU ERP system. They include: a long-term feedback, which changes when the maintenance issues are taken under consideration, and which must be taken back to into specification phase activities such as system performance, new requirements, the need of technical consultant support, etc. The second one is a short-term feedback, which takes enhancement back to the continuous enhancement phase activities such as user training and developing skills. The third one is technical impacts feedback that takes place into technical CSFs, which affect implantation success. As usually recognized, CSFs can be re-evaluated according to the ERP impacts.

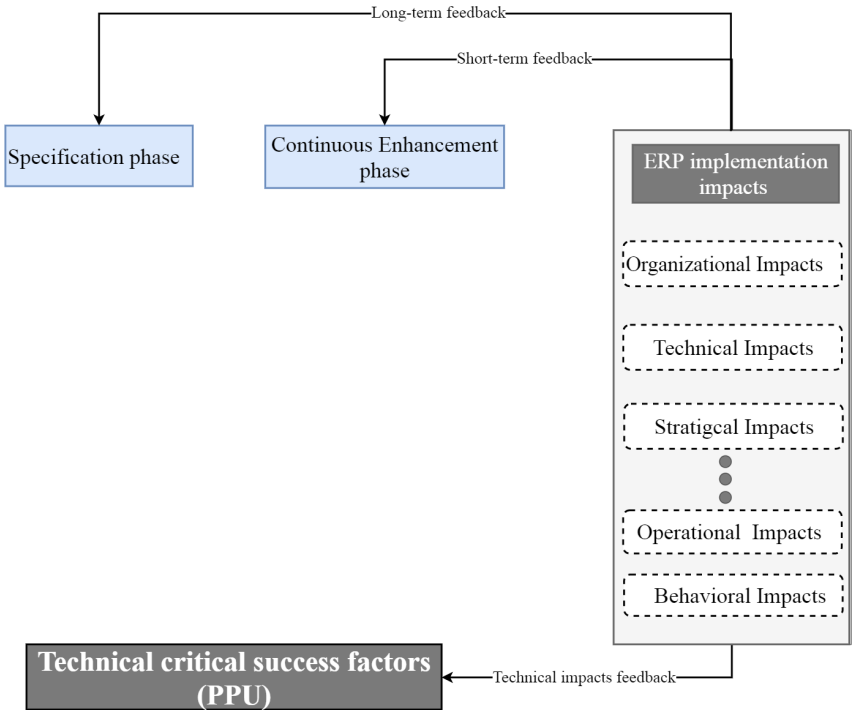

Figure 6.8: PPU's Post ERP system implementation impacts

6.1.10 ERP post-implementation success evaluation

There are some evaluation techniques to ensure whether or not the system is successful after being used in PPU. The gaps between the functions provided by the ERP system and those required and concerned by the university are common reasons for the poor performance. ERP is usually a packaged software system, which enables the university to use its resources efficiently and effectively by providing an integrated information processing solution [57]. ERP success evaluation models:

1. Delone and McLean is a common approach that is used to evaluate ERP post-implementation success by using an IS conceptual success models [58].

2. A model for evaluating ERP success, which is used by a fuzzy analytic network process [59].

3. Multi-aspectual ERP model relying on understanding of the end user's life-world for success evaluation [57].

4. Issue-based ERP assessment model in the post-implementation phase, which helps to assess the assimilation of organizations and ERP systems [60]. In the Figure below depict the historical improvement of evaluation models.

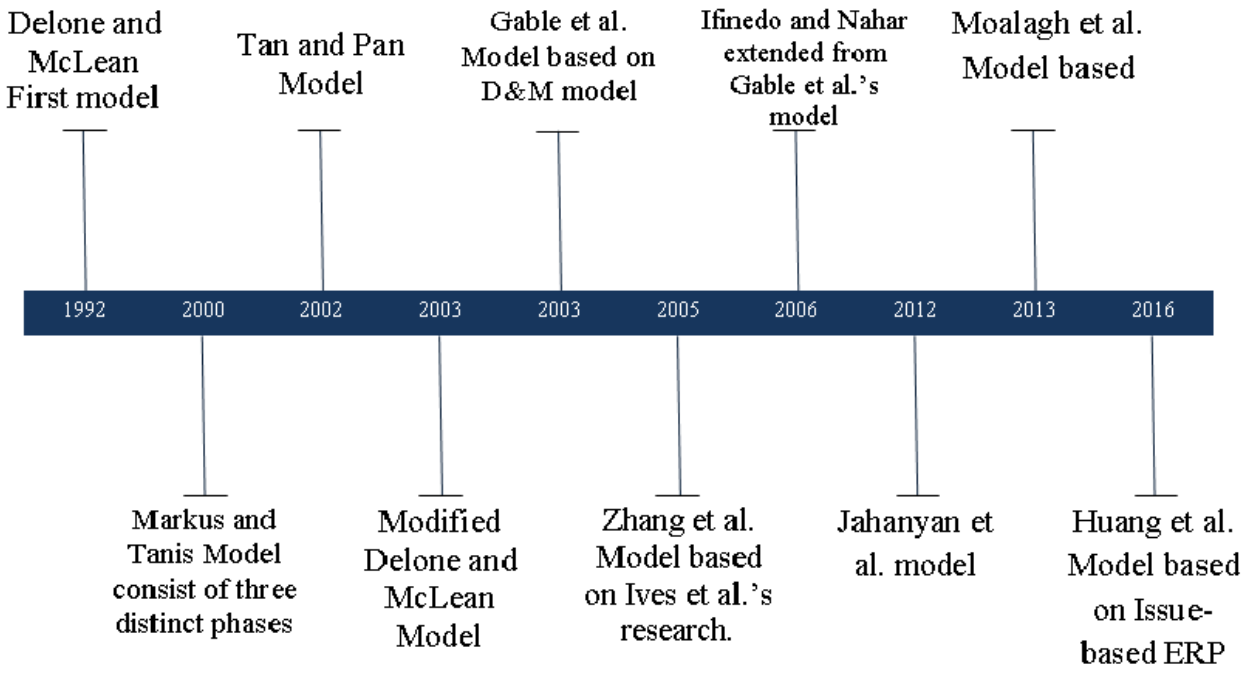

Figure 6.9: Historical improvement of evaluation models

Real evaluation of our ERP will take in fact 3-5 years in real environment. Therefore, this will be inevitably a future work.

Also, there are ERP systems quality models and metrics that are summarized in [61], PPU must use one of those quality models to assess its ERP system characteristic, as in the CSFs section there are some factors which can be considered as quality issues appeared as critical factors such as complexity and efficiency. But, it is important to know that metrics are considered qualitative indicators of ERP characteristics and the quality models demonstrate the relationships between metrics. Some of the quality models are listed below:

1. McCall's Quality Model.
2. Boehm's Quality Model.
3. FURPS Quality Model.

4. Dromey's Quality Model.

5. ISO 9126 Model.

6. ERPSQM.

6.2 University ERP framework validation

This section presents the validation process in the Figure 6.10 which used to validate our framework. Two procedures were used the first one we discussed with experts, and the second is a comparison.

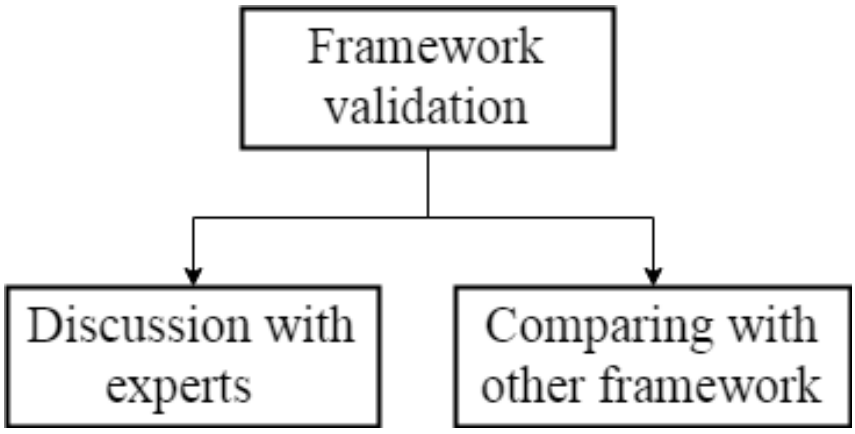

Figure 6.10: Validation flow

Firstly discussion with experts:

The model design validation form extracted from [62] and reflected to our framework's properties, where the form is represented in Table C.1. The experts gave their opinion according to their experience to improve the framework being more scientifically and rich in knowledge.
The validation was held by 4 experts were:

1. Dr. Isam Ishaq: assistant president for research, development, and innovation at Al-Quds University.

2. Dr. Ghassan Shahin: assistant professor at Palestine Polytechnic University.

3. Dr. Nancy Alrajei: assistant professor at Palestine Polytechnic University.

4. Dr. Omar Daher: assistant professor at Al-Quds University.

After the deep discussions with experts and take their feedbacks under account to improve and validate the PPU's ERP framework, the main modifications was:

1. Clarify the activities related to the integration phase on the framework.
2. Add the documentation and training phase with their main activities.
3. Decrease the project management scope.
4. Some changes in feedbacks lines.

Regarding the framework's content, all experts said it's clear and rich in knowledge. The modified university ERP framework is shown in Figure 6.11.

Secondly comparing PPU's ERP framework with other frameworks:.
We are compared our framework with [13] and the result summarized at the following Table 6.2.

Table 6.2: Frameworks Comparison

	Framework for [13]	Our framework
Cases	Concerned with just selection ERP packages	Three cases included (build, upgrade, select packages, and buy full ERP)
CSFs	Concerned with factor as extracted from literature	Technical success factors were extracted from our study.
Feedbacks	Not exists	Clear and explained
Related with software engineering practices	Not related	Highly related and core base
Number of stages	4 stages	9 stages
ERP implementation strategies	Not clear	Clear

The differences between PPU's ERP framework and [13] are:

1. The PPU's ERP framework took four cases under consideration according to the circumstances of the university. The university will choose the case which is suitable to it's needs:
    - Build new components.

- Upgrade the existing components.
- Select components (buy).
- Buy a full ERP packages.

2. The CSFs in the PPU's ERP framework are explored and analyzed particularly for technical field.
3. Feedback is required in order to enhance, follow up, apply evaluation, and prepare troubleshooting for PPU's ERP system.
4. Software engineering related, PPU's ERP framework is highly related in contrast to [13].
5. The number of framework stages: the PPU's ERP framework has 9 stages while [13] has 4 stages.
6. The ERP implementation strategies are clear in PPU's ERP framework in contrast to [13].

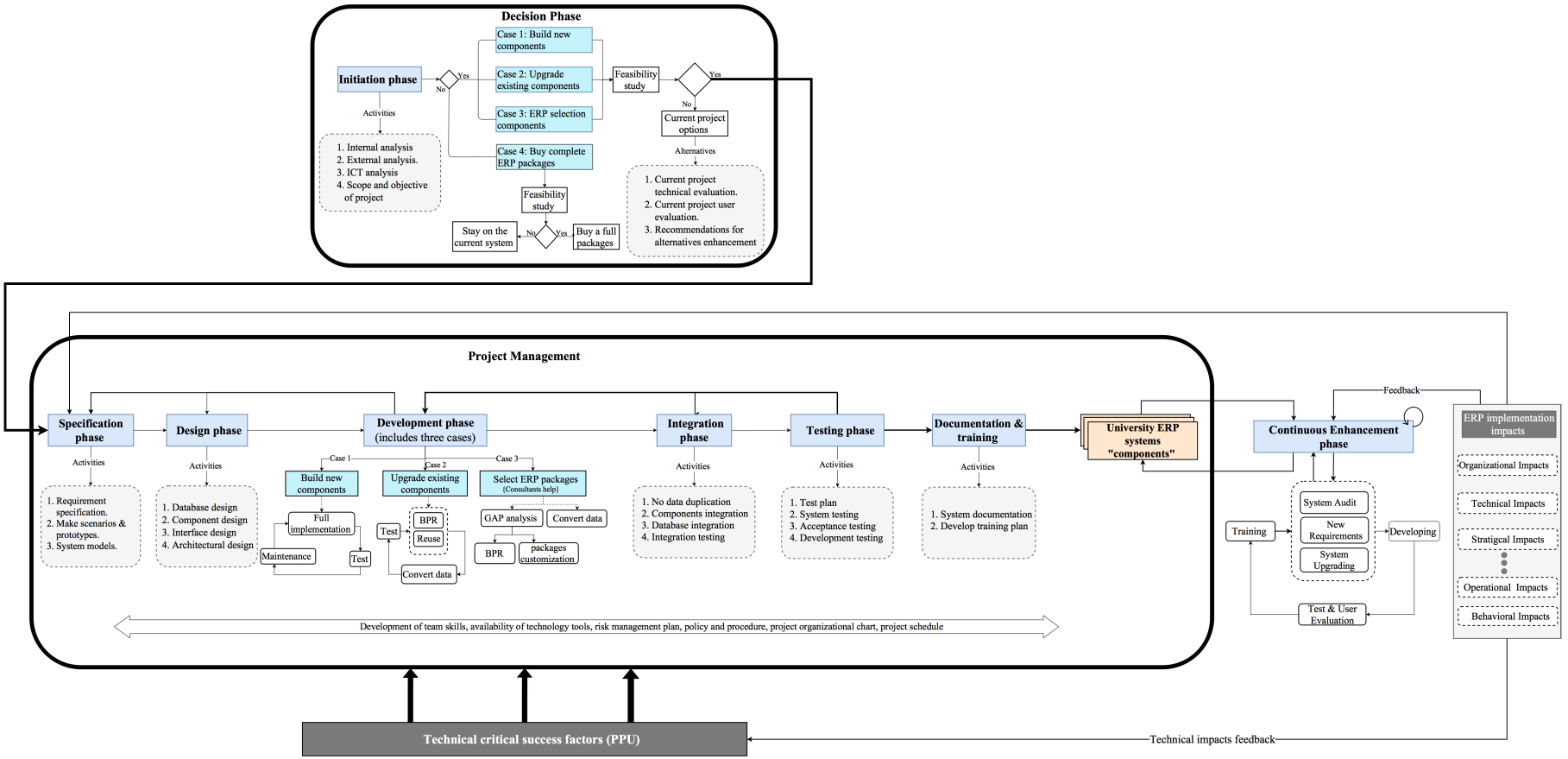

Figure 6.11: Modified PPU's ERP framework

6.3 Chapter summary

This chapter definitely focused on implementation of university ERP lifecycle. In addition, we present a software engineering perspective for presenting a full knowledge to universities about ERP pre-implementation planning. The study used PPU as a case study with concentration on studying and analyzing the current environment and situation to come up with requirements of building the ERP framework.

Our framework consists of: decision phase which contains the initial steps of preparations and decisions, feasibility study, technical options and university's internal and external environments. Specification phase is responsible for designation of university requirements. Design phase, which is responsible for designing the structure of the system and database aspects. Development phase, which consists of three cases: building new components, upgrading existing systems, and selecting packages where each case has a series of activities. Integration phase is concerned with system's components integrity aspects. Testing phase is responsible for ERP testing. Continuous enhancement phase is concerned with subsequent checkups and revisions. Essential elements of proposed framework emphasize on re-implementations and enhancements. The framework clarifies why organizations should apply the CSFs to assure achieving optimal success.

Chapter 7

Conclusion, Discussion and Future Work

In this chapter, we conclude the work performed in this thesis by summarizing our contributions. In second section, we will suggest some future research directions that can provide advantages to new researches.

7.1 Conclusion and Discussion

Enterprise Resource Planning (ERP) or integrated information solutions provides a controlling ability for all main business functions of the organizations and companies using an integrated information architecture. In addition, the main objective of implementing ERP systems is to connect all business units and all organization functions into a unified computer system that meets the requirements and satisfies the users of the organization.

Otherwise, universities exploit ERP system to take its advantages and to improve the information system they possess University ERP is defined as ”an information technology solution that integrates and automates recruitment, admissions, financial aid, student records, and most academic and administrative services [4]”. University administrative services include:

human resources, billing, accounting, and payroll. On the other hand, academic services include deployment, admission, registration, and all aspects of student records [63]. Therefore, university ERP systems are for nonprofit system used academic purposes while business organizations use ERP system for business purposes and earning profit [4].

The main aim of the ERP system is to integrate all the organization's departments and procedures across single computer device, which serves all departments and all of their functions and needs. The departments need to install a particular system to perform their work.

In this thesis, we took Palestine Polytechnic University (PPU) as a case study in order to help preparation of ERP implementation, to improve the information system in PPU. The current situation is fragmented and non-integrated systems in addition to different and redundant data identification.

Firstly: we studied and analyzed the differences between business ERP system and university ERP system, by intensive reviewing the literature. Covered topics include: structures, data, advantages, disadvantages, risks and challenges.

Secondly:we studied the missing parts of CSFs for university ERP system and presented their importance referring to literature and previous studies. Then we identified technical success factors as specific topic in order to acquire a successful ERP implementation by studying the PPU case study. Then, from the PPU current technical problems, we extracted the technical Critical Success Factors (CSFs) of PPU. The final list of CSFs 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 re-engineering.
11. Applying software engineering standards
12. Using unified theme of technology
13. Help menu
14. Documentation

The next section will discuss the recommended CSFs practises

7.1.1 Recommended technical CSFs and proposed practices

The implementation of the ERP system in the university is described as complex and difficult. We've decided to study the CSFs related to the universities' environment and to pay more attention to technical success factors. Our attention to the technical success factors surfaced after studying the literature and finding that there was a shortage of studies concerning this side of this field. Since a lot of researches and studies are conducted on the organizational or managerial factors without focusing on technical factors.

Therefore, being conscious of the CSFs that are highly related to the university can help to: reduce the risks in the PPU according to the current status, facilitate information access across the university in order to manage and plan the university, reduce the risk of business, and acquire better service for students, employees, and faculties [19]. Moreover, we decided to study the technical factors in particular. Furthermore, it is reported that large numbers of ERP system failure and inappropriate adoption are in higher education institutions, which also encouraged us to study the technical side further [64].

Therefore, the technical perspective will be concerned with planning the system itself, system infrastructure, system architecture, infrastructure, configuration and system customization, which will allow us to determine how to organize the implementation processes [14].

In the rest of the section we will explain our technical success factors and will give some proposed practices and knowledge that help PPU's decision makers and technicians to focus on.

Security

Security is the most important feature that the PPU is concerned with according to the survey results, as it is located under system dependability and reflects the system's ability to protect itself from external attacks whether accidental or intentional. If the security fails the result will be the loss of system availability, damaging of the data, information leakage [17] and reducing the process effectiveness and efficiency [65]. In the study [66] considers the security as sub characteristics of functionality, which poses the question; can the ERP prevent unauthorized access? Additionally, study of [67] mentioned the meaning of security and information security. Security means "Policies, procedures, and technical measures used to prevent unauthorized access, alteration, theft or physical damage." And information security means protection and controlling the information from legal access, unsuitable use or unauthorized access. Therefore, according to the internal documents of PPU [23] we found that there is a lack of staff in the information security manager areas. In addition, our study results show that the PPU's staff cares about security as a priority. This factor is ranked first of the technical critical success factors. Because of the multisite of the university and the importance of data security, the PPU look forward to achieve a high level of students' & employees' privacy, and this leads us to get a good data quality.

Subsequently, PPU must follow several steps to attempt to acquire security in their ERP system as referenced in [65]:

1. ERP system policy: it is the first step that PPU is concerned with in order to be ready to prepare the university to counter internal and external attacks, so the PPU must develop a set of security rules, practices, standards, activities, and procedures in order to preserve a

secure IT system.

2. Increase the employee awareness: increase the employees' awareness about security issues are one effective way to protect the university's data, by using classes, training programs, emails, presentations... etc.

3. Controlling the employees' access: PPU must put restricted actions to limit employees' access to different university's functions that are not related to their positions or include too much information that they will not be accessible to them.

4. Top management support: is the way that forces PPU's employees to comply with policies.

Training/Education

The university should prioritize the effective training for users who use ERP system, because of the highly positive relation between training and user satisfaction. [4]. Training helps to improve staff participation and involvement in the quality program by disseminating the priorities of the organization and its missions [63]. If the users are satisfied about their system they will not resist using it. In addition, training and education is considered as one of the management aspects to help to accept change, which helps users and employees to be able to understand all ERP concepts and proprieties, which will prepare them to use the new system [45].

According to the results of our study the PPU's staff considered training as a critical factor because of a high correlation between technology and the user of technology. Furthermore, the internal documents of PPU [23] mentioned that a lack of interest on the part of the staff -which use the IT system- in training, thus there was a poor participation in the training programs offered by the university. Otherwise, an appropriate training plan and developing the skills will set all control activities [13]. Without adequate and suitable training about 30% to 40% of frontline employees will not be able to handle the needs and requirements of the new system [63].

Training should include the development of information technology skills, In addition, online and printed manuals, lessons, workshops, tutorials, and help desks should be provided to support users and to ensure proper understanding of the function of the ERP system [19].

The study of [47] indicated that the role of the user training determined the success of the ERP implementation to nearly 42.20%.

Accodring to the different reading of training [68–70] the following flow Figure 7.1 was proposed training workflow for PPU: Identifying PPU training requirements & environment; identifying the training audience; developing university training plan: objective, scope, and trainers; and developing university training materials: tutorials, workshops and printed manuals.

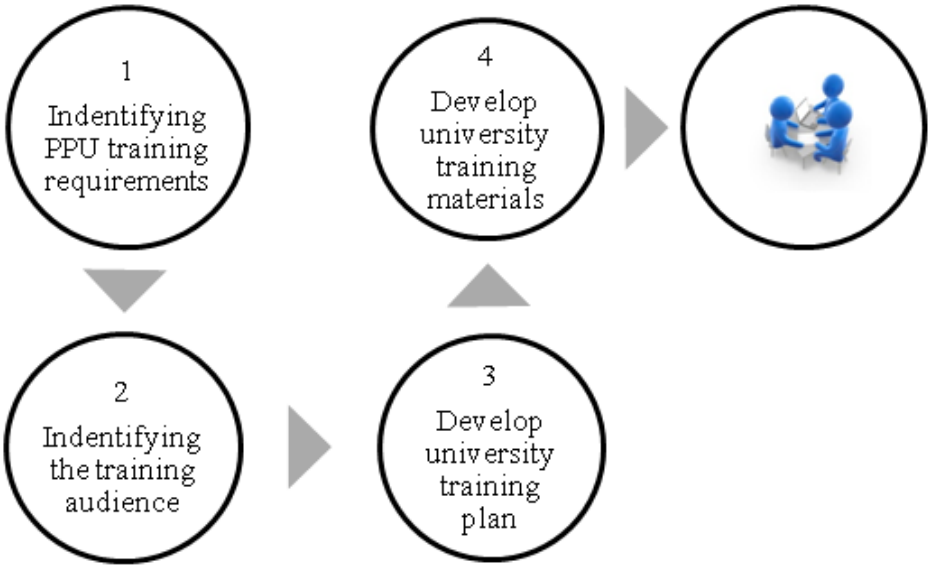

Figure 7.1: Proposed PPU training workflow [68–70]

Data analysis

Data analysis appeared as a critical factor result in the PPU because it is concerned with data, which is the core of any system in the word. Analyzing and keeping the quality of data was important to the PPU's staff. According to the internal document of the PPU [23] we found that there were no specialized data and system analyst who is able to analyze and determine the requirements, which the PPU needs. Also, internal documents pointed that in the PPU there is lack of staff in systems analysis areas, so it is important to shed the light on analysis of data and system. Therefore, the PPU should concentrate on recruiting specialized employees or developing their technical employees to cover the shortage of data and system analysis people. Because of the nature of the complex of ERP [71] and its containing of various packages and applications across the university or organization, it is important to analyze data and manages it correctly to ensure accuracy, since accuracy has a positive impact on system success [45].

Therefore, before starting coding, choosing packages, or reusing systems the PPU must ensure that there is a compatibility between data requirements and systems, besides preparing a data conversion plan [13].

System Integration

Integrating the system data will avoid duplication of data, which will increase the speed and reduce the cost. Therefore, to benefit of integrity it must begin with "increasing overall integrity and end with reducing the total cost of data protection" [13]. In the university there must be a good integration between applications that are involved in the ERP [4]. In addition, to the crucial professional database integration.

In the implementation of closely integrated ERP systems, universities are expected to perform a high level of information visibility and improvement of decision-making as well as to get the benefit of integration by obtaining better control and improvement of process and cost. The system integration is one of the CSF's, which are used and a priority during the deployment phase of ERP [55]; this underlines the importance of ensuring that all ERP modules' operations are connected smoothly, in order to have a successful implementation [72].

IT infrastructure

Identifying a new ERP system in the university requires some changes of existing technologies to increase the compatibility between technologies and to get maximum benefits from ERP systems. PPU staff considers IT infrastructure as a critical factor that should be taken under consideration during ERP implementation. Technology replacements will increase system risk and having skilled staff is a requirement [46]. The ERP system has a large architecture and infrastructure, therefore to ensure that they are sufficient, the developer must prioritize how the IT systems would be designed and built [14]. Clearly, the implementation of the planning system involves a complex transition from old systems and business processes to integrate the system with IT infrastructure and business operations across the university [47]. IT infrastructure support ERP system in three points [73]:

1. Flexibility of business changes in current and future.

2. Reduce IT costs.

3. Increase the capability of IT infrastructures.

IT infrastructure factor is considered as an indispensable factor, because the PPU must exploit the technological resources in order to be compatible with the university ERP system. Hence, the study of [47] indicated that the role of the technology infrastructure in determining the success of the ERP implementation is almost 38.40% .

Database administrator

Because of the nature of ERP -of having a centralized database- the technical staff in the PPU mentioned the importance of having a specialist of a database administrator in order to prioritize all data aspects and processes. According to the internal documents of PPU [23] we found that there is a lack of staff in database manager areas. The presence of unified database is important in order to collect all information and data from different system modules [74].

Complexity

The complex system consists of several applications that are linked together and their internal structure is linked as well [46]. Complexity is defined in IEEE 1991 as: “the degree to which a software system or one of its components has a design or implementation that is difficult to understand and verify”. Also, as defined in the book [75] defines complexity as: “a software system’s property that is proportional to the size of the system, the number of its constituent elements, the size and internal structure of each element, and the number and the nature of the elements’ interdependencies”.

PPU technical staff pointed that any system must be less complex to users and to the programmer. They also said that they are concerned about the complexity factor and are taking it into consideration when developing the current systems, in addition they believed that a high ERP system complexity is a reason of failure [76]. An ERP system is a complex system; it has many applications with numerous links, therefore, determining the system boundaries is important and must be clear from the beginning to help in achieving success [46].

Efficiency

Efficiency defined as: " a quality that reflects a software system's ability to meet its performance requirements while minimizing its usage if the resources in its computing environment. In other words, efficiency is a measure if a system's resource usage economy" [75]. Moreover, you can define efficiency as the amount of effort required to accomplish the task by "measuring the number of actions or steps that users took in performing each task [77]".

As noticed during interviews the PPU technicians have a good awareness regarding the efficiency definition and they always tried to accomplish nonfunctional aspects besides functional ones. One of the efficiency sub factor according to [61] is the time behavior which poses the question of how quickly does the ERP system respond?

Although flexibility is not a consequent of the factors that we study, I think that it is related to efficiency and it is an important part where the programmer must focus on because of the nature of interconnected factors, which the ERP system has. There are four dimensions of system flexibility: parametric flexibility; defining university needs as parameters, code changes; changing may happen in all system segments, module addition, and connectivity to other systems [46].

System robustness and error prevention

To ensure success of the ERP system between packages in the university system we need properly managed, integrated activities so that this integration must be tested, robust, troubleshot and error prevention, certainly theses aspects is important to achieve desired ERP functions [45]

Software robustness is a significant feature of any system, it can be defined as the degree of the system or component, which can work correctly in the presence of incorrect input or stressful environmental conditions. Also, it is an element in achieving system dependability [78]. "Robust systems deliver their intended functionality under varying operating conditions without being changed [79]".

Robustness is a system non-functional requirement and is used to assess a system's ability to preserve stable design parameters in a confrontation of disorders either individual or simultaneous

external or internal. Robustness can be influenced by systems' designers where they construct complex systems with a meaningful configuration and redundancy of internal component, which realizes functionality and performance [80].

Business Process Reengineering (BPR)

Make some changes in the process and organizations workflow with the ERP system implementation [4]. The goal behind it is to focus on packages that are incompatible with organization needs and business processes. Therefore, to achieve a match between packages and business process, it is better to re-engineer the business process to fit the packages instead of doing the opposite. Meanwhile, high customization will increase the possibility of errors and costs [45] . In the study of [47] indicated that the role of the BPR in determining the success of the ERP implementation is almost 44.20%.

According to the experiences of PPU technical staff, they pointed out to the necessity to change some university's processes and operations. However, too much system customization may cause system implementation to fail and it will increase the project time, schedule breakdown, new bugs, and the updated system will be difficult [13]. It is better to minimize customization as much as possible [19]. Precise and adequate matching between university process and software packages is important to attain the ERP success [45].

Thirdly: we studied the degree of using software engineering practices by the university's staff in order to evaluate how much they can build a new complicated system in the right theoretical way. As a result, we are using it to improve a model for PPU ERP implementation. Also, all notes, interview, results, and internal documents were used to build the model. The model includes nine phases in addition to post implantation issues; all operations, process, and options were discussed. **The university ERP framework summary** is:

1. Decision phase: this phase responsible for making initial steps that help the technical decision makers to decide the ERP solutions. It includes three main activities, initiation phase, ERP solution cases, and feasibility study.

    a) Initial phase is responsible for studying and analyzing PPU environments.

b) ERP solution cases, the main objective of these cases is to decide the most appropriate case for implementing a university ERP system.

c) Feasibility study is used to decide if the system development is feasible to develop or not.

2. Software specifications phase: are responsible for developing and extracting software requirements. The phase activities:

   a) Making requirements elicitation.

   b) Making a scenarios and prototype constructions.

   c) Making system models.

3. Software design phase: this phase describes the structure of the system, which intends to be implemented and indicates the models of data and structures that will be used by the system, interfaces between components of the system, etc. The phase activities:

   a) Database design.

   b) Component design.

   c) Interface design.

   d) Architectural design.

4. Software development phase: this phase is the core of development process. It is responsible for converting system requirements and specifications into an executable system during the process of software development. The phase activities:

   a) Case one: build new components (full implementation, test, and maintenance).

   b) Case two: upgrading existing components (BPR, reuse, convert data, and test).

   c) Case three: ERP selection (GAP analysis, BPR, customization, and conversion plan).

5. Integration phase: this phase is responsible for integrating of all university components. The phase activities:

   a) Insure nor duplicated data.

   b) Component integration.

c) Database integration.

d) Integration testing.

6. Testing phase: testing is considered as a real validation and verification processes of any software. The phase activities:

   a) Test plan.

   b) System testing.

   c) Acceptance testing.

   d) Development testing.

7. Project management: is using the skills and knowledge in coordinating the project schedules and to monitor the project activities to ensure achieving the objectives. The phase activities:

   a) Project progress reports.

   b) Risk management plan.

   c) Project's activities by milestones.

   d) Project schedules.

   e) policies and procedures.

8. Documentation and training phase: the objective of this phase is to get the system documentations and manuals, and to train the users to use the system. The phase activities:

   a) System documentation.

   b) Develop training plan and requirements.

9. ERP continuous enhancement phase : the objective of this phase is to identify the maintenance and support activities that university integrated ERP systems need. The phase activities:

   a) System audit.

   b) New requirements.

c) System upgrading.

d) Test and user evaluation.

e) Training.

The main goal of ERP implementation framework is to achieve a successful implementation. The PPU's ERP framework processes are a mixed series of technical, strategies, and collaborative activities, in addition to management with the general goal of identifying, designing, implementing and testing the software system. Also, software developers use a lot of different tools to support their software work. Tools are especially valuable to support the liberalization of different types of documents and to manage the vast amount of detailed data and information that is produced in the large project of the software.

7.2 Future Work

This thesis contributions is to build a solid base of preparing an ERP system at PPU, thus, the domain of future studies will be wide. Other success factors category includes:

1. Organizational factors.
2. Individual factors.
3. Cultural factors.
4. Social factors.
5. Political perspectives factors.

In future, we will study the challenges and risks that may occur specifically in universities. It is hence important to study quality system characteristics and subjects, in addition to choosing the suitable evaluation strategies and techniques, and must be undertaken after using university ERP system and during the implementation. The ERP system is very complex in nature and so scope of the study is wide and diverse.

7.2.1 Future ERP evaluation plan

The aim of this section is to measure the perceived acceptance of the ERP system in the university after three to five years of using, and to propose a future plan for the ERP evaluation. System evaluation techniques are wide. We mentioned some evaluation models with different dimensions in chapter 6.

- **Delone and McLean IS model - User satisfaction perspective**

This questionnaire will use the conceptual model of Delone and McLean (2003) which are a modified version of Delone and McLean model (1992). This model attempts to provide an inclusive understanding of information system success by identifying, describing, and clarifying the relationships between six dimensions of success along which information systems are commonly evaluated. [58].

We used this model as it is a widely used model and the most validated measure that is used to evaluate information systems and ERP post-implementation success [58, 81].
The Delone and McLean model has been used to evaluate the IS in a number of different researches. For example, it has been applied in some studies to validate the success of e-commerce systems as study [82], knowledge management systems as study [83], in addition to using this model to assess the ERP systems such as [84–86] and many studies that are using the Delone and McLean model. Our evaluation plan will study the user's perception about the IS measures, and the influence users' satisfaction of the PPU's ERP system [81]. As shown in the Table 7.1. The IS measures are:

1. System quality.
2. Information quality.
3. Service quality.
4. Technology.
5. IT self efficacy in university.

6. Net system benefits.

Table 7.1: Delone and McLean IS model for ERP evaluation

User satisfaction					
Measures	**1**	**2**	**3**	**4**	**5**
System Quality					
ERP system is easy to use					
I am satisfied with the speed of the ERP system					
I am satisfied with how quickly the ERP loads pages and images					
The user interface of ERP system measures up to global standard					
Information Quality					
The information on the ERP system is always timely (timeliness)					
The information on the ERP system is always accurate (accuracy)					
The information on the ERP system is usually relevant (relevance)					
Service Quality					
The support staff of PPU are technically competent (competence)					
The support staff of PPU are fast in attending to complaint (speed)					
The support staff of PPU are very reliable (reliability)					
Technological and Infrastructural Issues					
Unstable power supply is a major challenge to user satisfaction					
The ERP system is very slow and need to be upgraded					
Lack of sufficient internet facilities around the university limits user satisfaction					
I.T Self Efficacy					
I find it easy to use the ERP system because I am computer literate					
I can search for information on the internet					
I can create groups on Facebook					
User Satisfaction					
I am satisfied with the overall system quality of ERP system					
I am satisfied with the overall information quality of ERP system					
I am satisfied with the overall service quality of ERP system					

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Appendix A

First questionnaire

Dear interviewee:

We are collecting the following information for a study titled ”PREPARING FOR UNIVERSITY ERP SYSTEM– TECHNICAL AND SOFTWARE ENGINEERING PERSPECTIVE”. Information and data that you provide is highly valuable for our research.

- The study aims (Pilot survey): The questionnaire aims to study the technical problems that current systems in the PPU suffer.
- This questionnaire will be fulfilled only by technical staff in PPU.
- The questionnaire is organized in 3 parts:
    1. First part in the questionnaire: includes demographic information.
    2. The second part: includes the questionnaire number Two: which asks you to answer ”What technical problems do you observe in your current system?
    3. Third part: Open Question: What technical problems that exist in your current system are not contained in part one?

Part One: Demographic information.

Select your gender:

1. Male.
2. Female.

Select your position:

1. Managerial employee.
2. Academic employee.
3. Technical employee.
4. Other:.....

Experience Field:

1. Programmer.
2. Software Engineering.
3. Computer Engineering.
4. Other:.....

Experience years:

1. Inside the university:.....
2. Outside the university:.....

Certification level:

1. Diploma.

2. Bachelor.

3. Master.

4. PhD.

Academic University Specialization:.....

Part Two: What technical problems do you observe in your current system?

Table A.1: First questionnaire: technical problem

Questions	Extremely disagree	Disagree	Undecided	Agree	Extremely agree
The current system was designed to be less complex structures.					
The network in the current system is reliable.					
The current system was designed to be flexible.					
The use of the current system is efficient.					
The current system responses to user's requests quickly.					
A good data quality is a feature that took under consideration when provided to the current systems' implementation.					
The current systems have an easy data conversion mechanism.					
The current systems have a redundant data.					
Processes' workflows in the university are managed correctly.					
The current systems are designed to provide useful and needed alerts.					
The current systems are highly customized with business processes.					
The current system interfaces are designed to be user friendly.					
Help manuals, and documentations are always provided to user in the current systems.					
The current system's status is an aspect is always you concern to be visible to user.					
One of the current systems' characteristics is robustness.					
One of the current systems' characteristics is prevention errors.					
Frequent development and testing are activities that current systems reveal.					
The current systems are tested.					

Part Three: Open Question What are technical problems do you think which are exist in your current system are not contained in the part two?

Appendix B

Second questionnaire

Dear interviewee: We are collecting the following information for a study titled ”PREPARING FOR UNIVERSITY ERP SYSTEM– TECHNICAL AND SOFTWARE ENGINEERING PERSPECTIVE ”. Information and data that you provide is highly valuable for our research.

- This questionnaire will be fulfilled only by technical staff in PPU.

- The questionnaire is organized in 3 parts:

  1. **First part:** includes demographic information.
  2. **Second part:** includes the questionnaire number Two:: What were the most Critical Factors enabling the technical successful ERP project implementation?
  3. **Third part:** studying the degree of software engineering activities which are followed during systems processes implementation at PPU.

Part One: Demographic information.

Select your gender:

1. Male.
2. Female.

Select your position:

1. Managerial employee.
2. Academic employee.
3. Technical employee.
4. Other:.....

Experience Field:

1. Programmer.
2. Software Engineering.
3. Computer Engineering.
4. Other:.....

Experience years:

1. Inside the university:.....
2. Outside the university:.....

Certification level:

1. Diploma.
2. Bachelor.

3. Master.

4. PhD.

Academic University Specialization:.....

Part Two: What were the most Critical Factors enabling the technical successful ERP project implementation?

Table B.1: Second questionnaire: technical CSFs

	Factors	Extremely not critical	Not critical	Undecided	Critical	Extremely critical
1.	Complexity					
2.	Network Reliability					
3.	Flexibility.					
4.	Efficiency of Use					
5.	System's Response Time to Users' Requests					
6.	Data Quality					
7.	Data analysis					
8.	Data Conversion					
9.	Minimum customization					
10.	User friendliness					
11.	Help menu					
12.	Documentation					
13.	Visibility of the System's Status					
14.	Robustness and Error Prevention					
15.	Software Development,					
16.	Software testing and Troubleshooting					
17.	Security					
18.	IT infrastructure					
19.	Business process reengineering					
20.	Applying software engineering standards					
21.	Database administrator					
22.	Using unified theme of technology					
23.	System integration.					
24.	Training.					

Part Three: The aim of this questionnaire: is studying the degree of software engineering activities which are followed during systems processes implementation at PPU.

Table B.2: The questionnaire of software engineering activities in PPU

Measures	Extremely disagree	Disagree	Undecided	Agree	Extremely agree
Project Management					
Project activities are always determined by milestones.					
Employees send the progress reports frequently to the manager.					
Project schedules (eg: activity chart, bar chart) are always set.					
The staff always creates a risk management plan for the project.					
Software Specification or Requirements Engineering					
We always make a feasibility study.					
We always concern to make an elicitation and specification of requirements.					
We always make a scenarios and prototype constructions					
We always make system models.					
Software Design					
We always do an Architectural design					
We always do an Interface design					
We always do a Component design					
We always do a Database design					
Software Development					
There is a high turnover rate of the project developers' team members.					
Your technical team members are well skilled					
There is availability of technology tools which support the capabilities and productivity.					
System documentations are always done.					
We have a conversion plan.					
Testing					
We always have a test plan.					
We always do a Development testing					
We always do a System testing					
We always do an Acceptance testing					
Standard Software Engineering Practices					
Following software engineering practices increases the probability success of the system.					
We have full awareness of these practices during the implementation process of the systems' life cycle.					
We always follow one of the software engineering methodologies during the implementation process.					

Appendix C

Validation form

Table C.1: The model design validation form [62]

Item	Strongly Agree	**Agree**	**Neutral**	**Disagree**	Strongly Disagree
A.The model is					
1. Understandable					
2. Clear					
3. Complete					
4. Comprehensive					
5. Self-explained					
B. The graphical representation (layout) of the model is:					
6. Understandable					
7. Clear					
8. Complete					
9. Comprehensive					
10. Matching,the textual explanation					
C. The textual explanation of the model is					
11. Understandable					
12. Clear					
13. Complete					
14. Comprehensive					
D. The components are all					
15. Understandable					
16. Necessary					
17. Relevant					
18. Sufficient					
Continued on next page					

E. The relationships between components are					
19. Understandable					
20. Clear					
21. Meaningful					
F. The graphical representation of the components is					
22. Understandable					
23. Clear					
24. suitable					
G. 'Decision phase' component is					
25. Necessary					
26. In the right place					
G.1. 'Initial phase' components are:					
27. Necessary					
28. In the right place					
29. Sufficient					
G.2. 'Cases' components are:					
30. Necessary					
31. In the right place					
32. Clear					
G.3. 'Alternatives' components are:					
33. Necessary					
34. In the right place					
H.' Development phase' components:					
H.1. ' Development phase-case one' components are :					
35. Necessary					
36. In the right place					
37. Sufficient					
38. Complete					
H.2. ' Development phase-case two' components are :					
39. Necessary					
40. In the right place					
41. Sufficient					
42. Complete					
H.3. Development phase-case three' components are :					
43. Necessary					
44. In the right place					
45. Sufficient					
46. Complete					
Continued on next page					

48. In the right place					
J. ' Continuous enhancement phase ' component is :					
49. Necessary					
50. In the right place					
K. 'ERP implementation impacts',component is :					
52. Necessary					
53. In the right place					