THE APPLICABILITY OF A COLLABORATIVELY-DEVELOPED ENTERPRISE RESOURCE PLANNING (CD-ERP) APPROACH IN LIBYAN HIGHER EDUCATION:

Libyan Universities as a Model

A Thesis Submitted to Wrocław University of Science and Technology in Fulfilling the Requirements of the Doctorate Degree in the Faculty of Computer Science and Management

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CANDIDATE'S DECLARATION

I confirm that this research was carried out in accordance with the regulations of Wrocław University of Science and Technology, Wrocław/Poland. I also confirm that it is original and the result of my own work, unless indicated or acknowledged as a referenced work otherwise. I also confirm that this topic has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

I hereby declare that in the event of the above information is found to be false, untrue, misleading or incomplete, I am aware that I may be held liable for it.

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Candidate's Signature ……..

Date: ……..

DEDICATION

This thesis is dedicated to all of my family members and friends.

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I would like to thank both of my supervisors, namely: Prof. David Ramsey (Senior Supervisor) and Dr. Anna Lamek (Assistant Supervisor) for their patient, guidance, advice, and encouragement all the way through this doctorate journey. The accomplishment of this research reflects how lucky I was to have such professional supervisors.

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I would finally like to thank all persons that participated or helped me during the fieldwork in Libya, especially those from University of Tripoli, Misurata University and Sirte University.

ABSTRACT

As a developing country, Libya is struggling to invest more in Information and Communication Technology (ICT) in several segments. The Higher Education (HE) sector is one vital segment that needs extensive enhancement of Information Technology (IT). Using IT effectively in HE is considered to be a requirement for enhancing its performance. The issue of Information System (IS) development is a crucial part of IT. Like other HE institutes all over the world, Libyan universities have continuously been working on developing their own ISs or adopting commercial solutions. Both models have shown negative results to some degree. This research was, therefore, to investigate the applicability of a collaborative approach based on community source paradigm in Libyan Higher Education (LHE). This approach is an alternative and an intermediate model between two well-known models (closed and open source systems). Worldwide, similar projects are found in many countries that include the USOS project and MUCI consortium in Poland. The community source paradigm is referred to as the collaborative development approach in this research. Besides other factors, ERP was included in the study to avoid the barrier of rebuilding systems from scratch.

To investigate this approach, three main methods were applied. Firstly, a deductive method was followed, in which a narrative literature review was used to draw conclusions about the key elements. Secondly, lessons learnt from international cases of similar projects were included. Many of the issues observed in these projects are similar to those found by the author in the literature. Within this frame of reference, the variables of the research were defined, and a number of hypotheses were developed. Thirdly, an inductive method was followed in studying the Libyan context to test hypotheses. Three public universities (used as a model to LHE) were studied to assess the ISs implemented in these case studies. Qualitative data were gathered through surveys in Libya. In order to study these cases consistently, a model of business activities in HE institutes was adopted from (Zornada & Velkavrh, 2005). Besides this, the University of Tripoli was treated as the subject of an initial study to identify any practical problems in the research procedure before conducting the formal study. After conducting the formal study, an assessment framework was developed to analyze the data gathered during the fieldwork. The assessment framework was constructed on the basis of selected techniques and models, specifically: system profiling and process mapping of ISs, Nolan's model, Zuboff's model, and the CPIT model.

The analysis indicated the low-level at which ISs are implemented in LHE at university-level, as well as the lack of capability for system development within these universities. These findings were used to assess the hypotheses developed by the author regarding the applicability of a collaborative approach in LHE. Other findings have supported this applicability, such as the fact that cooperation in the IT-field between Libyan universities has already started, and the positive feedback from participants about the applicability of such an approach. Hence, the Collaboratively-Developed Enterprise

Resource Planning (abbreviated to CD-ERP) model was constructed on the basis of the findings from the fieldwork in Libya, and taking into consideration the observations from both the literature and similar projects (community source projects). In this context, the CD-ERP model was proposed as an output of this research that provides a promising solution for LHE, including a proposed structure of the consortium, development structure, and cloud architecture, alongside several recommendations for successful and efficient transformation from their current systems to a collaborative approach. Furthermore, a strategic view of the CD-ERP model was discussed on the basis of SWOT analysis. Moreover, a hybrid approach to development under the CD-ERP model using agile practice was introduced. Since this research is an introductory description of the model, the limitations and future work were eventually discussed.

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Published papers:

1) Managerial Perspective: “Information Management in a Collaboratively-Developed Approach to Enterprise Resource Planning – A Higher Education Perspective”, MDPI-Information 2020, 11(3), 146.

2) Initial Study – Part 1: “Evaluation of the Performance of Information Systems Implemented at the University of Tripoli, Libya”, was published in the Proceedings of the 11th International Conference on Knowledge Management and Information Systems, Vienna, Austria, 2019, published in SCITEPRESS. This paper presents the results of the initial study, which was conducted on the first subject (UOT).

3) Initial Study – Part 2: "Using the SERVQUAL Model to Assess Service Quality and Students’ Satisfaction (An Empirical Study of the Online Registration System at the University of Tripoli)", was published in the Proceedings of the 3rd International Conference on Business and Information Management (ICBIM 2019)", Paris, France, 2019, published in (ACM) Association for Computing Machinery.

4) Analysis of Critical Success Factors: "An Empirical Analysis of Critical Success Factors for CD-ERP Model", was published in the Journal of Computers JCP, ISSN: 1796 203X). Abstracting/Indexing: DBLP, EBSCO, ProQuest, INSPEC, ULRICH's Periodicals Directory, WorldCat, CNKI.

5) Formal Study: "Approach to the Methodological Assessment of the Performance of Information Systems at Libyan Universities (Based on Multiple Case Studies)", was published in the International Journal of e-Education, e-Business, e Management and e-Learning (IJEEEE, ISSN: 2010 3654). Abstracting/ Indexing: EBSCO, Google Scholar, Electronic Journals Library, QUALIS, ProQuest, EI (INSPEC, IET).

6) Proposed Model: "A Collaboratively-Developed Enterprise Resource Planning (CD-ERP) Approach in Libyan Higher Education", was published in the International Journal of Information and Education Technology IJ IET, ISSN:2 010 3 689 Online)). Abstracting/ Indexing: Scopus (Since 2019), EI (INSPEC, IET), EBSCO, Electronic Journals Library, Google Scholar, Crossref.

Paper accepted for publications:

7) "Using Agile Practice under the CD-ERP Model: A Hybrid Approach", the Econometrics Journal - Informatyka Ekonomiczna (Business Informatics).

8) "Practices of the Circular Economy in Community Source Projects: A Preliminary Study", the Econometrics Journal - Informatyka Ekonomiczna (Business Informatics).

Seminars and Talks:

- 08/06/2017: a talk at the faculty seminar to introduce the project.
- 20/06/2017: a seminar to the department committee. It was voted to open the doctorate project in the department.
- 13/12/2018: a talk at the faculty seminar regarding the research progress.
- 05/03/2020: a talk at the faculty seminar regarding the results and findings of the research.
- 17/02/2021: a talk at the seminar of the management systems department at the faculty to obtain further comments from different department in order to enrich the quality of the research.

CHAPTER ONE: INTRODUCTION

1.1. Statement of the Problem

Based on the Global Competitiveness Report 2003-2014 regarding education ranking, Libya is placed 108th out of 148 countries providing higher education (HE). Thus, it falls in the bottom third of the countries surveyed. Consequently, the Libyan higher education (LHE) system has failed to achieve its goals. (Elferjan, 2015) examined training as a factor required to enhance the education system, while (Bakeer & Wynn, 2014) investigated the utilization of information and communication technology (ICT) in Libyan universities. Few other studies have investigated related factors. This has led to a lack of available research and literature covering the problems and issues related to ICT in LHE, in particular concerning universities. ICT is considered here because it is increasingly acknowledged that using technology effectively in HE is a vital factor for providing better education. Concentration on ICT adoption and its transformation in Libyan universities is unavoidable, to enhance the HE system and achieve its objectives. Information Systems (ISs) are an important issue in ICT and there has recently been intensive work towards using ISs to improve the efficiency and effectiveness of Libyan Public universities. Although some universities have been negatively affected by the Libyan civil war (2011-present), the current stability (a form of frozen conflict) in the country has given universities the chance to develop their business and information system strategies. Nevertheless, the real challenge concerns how to create continuous professional development in ISs for university staff, students, researchers, and other stakeholders.

The author has been working in the field of IS development at UOT since 2012. From his experience, IS development is a critical issue at UOT and a similar view seems to be held in the majority of Libyan universities. Due to the lack of research conducted on this issue, it is not clear what obstacles will be faced when more advanced ISs are implemented at Libyan universities. The question of what approach should be used to implement more advanced ISs in LHE is thus potentially of great practical and academic interest.

As in other HE organizations worldwide, Libyan universities find themselves in a rapidly and intensively changing environment, which leads them to a crossroads situation: *Should they buy commercial ISs or develop in-house applications?* The former may be hard to customize based on organizations' specific desires, while the latter are often too ambitious and many organizations find it impractical to acquire the necessary competence for developing software themselves (Liu, et al., 2015). Collaboratively developed IS approach - or what is also known as the "community-source" approach - provides a practical alternative to these solutions by combining effectively the benefits of in-house development and outsourcing. This approach aims to pool institutional resources to develop open source applications, which dramatically reduces the development costs in HE organizations (Liu & Qiang, 2011).

"Community-based open source" is also described in short as "community-source", while in this research it is called "collaboratively developed IS approach". It was first proposed by Brad Wheeler and defined as an open source project that is governed by a group of educational institutions or even firms (Wheeler & Hilton, 2012). Using a community-source approach, a consortium of partners share their financial efforts and human resources to complete a project. This project is managed through a standard model of consortium governance (Hanganu, 2008).

Rebuilding systems from scratch could also be a considerable barrier. From this point of view, a base system should be adopted before developing an advanced IS. Expecting the ISs in Libyan universities to be at a low-level of advancement, Enterprise Resource Planning (ERP) is thus considered in playing the role of a base system. However, the high establishment and operational costs in ERP implementation present a major disadvantage (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011) (Zornada & Velkavrh, 2005), especially as public universities are non-profit organizations and depend on the government as a financial sponsor. That is why many colleges and universities have chosen to follow a non-ERP approach by reinvesting in their existing legacy systems. These institutions believe that this strategy involves less risk and cost than carrying out new implementations and is better aligned with their goals, culture, and directions.

On the other hand, the disadvantage of high establishment and operational costs should theoretically be avoided by following a collaborative approach, which leads to sharing such costs. Such an approach needs a group of enterprises that are similar in organizational structure, data flow, and business processes. Also, we should not forget that the concept of information technology (IT) has been shifting from building to consuming, where cloud computing (CC) has emerged as a sustainable and promising solution to the challenges associated with shrinking IT budgets and escalating IT needs. Hence, CC and Multi-tenancy are also considered as additional factors and are also discussed in the conceptual framework of this study.

Libyan public universities could benefit from a collaborative approach to developing ISs under the direction of the Ministry of Education. The author, therefore, has investigated such an approach in the Libyan context through comparison with other possible approaches. Further reasons for studying this topic are as follows:

- The issue of IS development in HE institutions worldwide, especially regarding collaborative development, is a topic that has received increasing attention recently at international and local levels.
- The limited number of studies (according to the researcher's knowledge) that deal with the assessment and development of ISs in LHE institutions.
- Providing a reference to guide the understanding of the process of applying the collaborative approach in HE institutions locally and regionally, neighboring countries might benefit from studying the case of Libya.

- This research could be useful for decision makers in identifying the obstacles facing IS development in LHE institutions, and factors for successful implementation.
- Providing an opening gate for more studies on the issue of IS development in HE, both in Libya and internationally.

1.2. Related Studies

In order not to confuse terms, this study deals with the approach of developing ISs collaboratively via a consortium of HE institutes, rather than such a consortium itself. In particular, the applicability of such an approach to LHE using Libyan universities as a model was studied by examining the Libyan context and considering international experiences. To the author's knowledge, this study is the first to deal with both sides. In fact, little attention has been paid to international experiences of the community-source approach. The studies that have been carried out on these projects generally regard their technical issues, rather than the consortium itself. In reality, consortiums between universities have existed for a long time, e.g. the CINECA project in Italy (Vertiv, 2018) which dates back to 1969, while the community-source paradigm was first applied by the KUALI (Liu, et al., 2015) and SAKAI projects (Alves, et al., 2012), (Ignjatovic & Jovanovic, 2013) in the United States. Other studies have been conducted on USOS in Poland (Czerniak, 2010), the Sigma Suite and the CRIS Argos Suite in Spain (Cuni, 2014), the FS University Consortium in Norway (Paulsen, 2002), the AMUE system in France (Desnos, 2001), Ladok in Sweden (Feasibility-study, 2012), and HisinOne in Germany (Hubner, et al., 2008). Some of these projects are covered in *Chapter Four: International Experiences*.

On the Libyan side, Bakeer and Wynn have done three studies on IS implementation in Libyan universities (Bakeer & Wynn, 2014). They investigated Misurata University as a case study, unlike this study in which multiple cases were chosen. Also, they treated ISs and e-solutions alike, while this thesis treats them separately. This provides a much wider view, as will be shown in the Analysis section. Also, IS deployment in Libyan oil companies was assessed using similar methods by (Akeel, et al., 2013). All of these studies investigated IS implemented from a managerial or strategic perspective, unlike this study, whose aim is to assess the level of ISs in these universities and to assess their readiness for developing more advanced systems. Indeed, those studies neither discussed the development level of ISs in Libyan universities as a whole, nor suggested any solutions. In contrast, this study proposes a solution to the issue of developing ISs by considering community-source approaches.

1.3. Research Questions

The research project aimed to answer the following research questions:

What similarities and differences are there among approaches to system development?

This question deals with "*WHAT the current system is*" and "*HOW the system should be developed*". Some sub-questions that need to be answered are: What are the benefits and drawbacks of various approaches in the context of LHE at university level? If Libyan universities abandon a non-ERP approach in favor of an ERP-based approach, what are the risks and consequences? What benefits can be gained and what difficulties are expected using a collaborative-development approach compared to the approach of universities individually carrying out separate projects? To answer this question, a comparison of approaches to system development is conducted, with supportive observations from international projects.

How successful have other international projects been and what can be learnt from their experiences?

To answer this question, cases of international projects following similar approaches were included (based on reviews of the documentation from international projects).

How does the implementation of ISs in LHE look in the XXI century after years of serious technical, economic and social development?

To answer this question, an assessment of the implementation of ISs in LHE at university level was conducted by using an assessment framework to look deeply at the level of these ISs and to check whether or not Libyan universities are capable of building and implementing their own systems (in-house applications). Also, the unique characteristics of Libyan universities and their special needs were defined. Three case studies were conducted for comparison and to draw conclusions.

What approach to IS development is best suited to the size and needs of Libyan universities, and what is the most practical method of transformation?

To answer this question based on the observations from international experiences, the Libyan context using Libyan universities as a model, and observations from relevant literature, a collaborative approach is constructed that includes: the proposed model of collaboration, the business model of the consortium, the consortium structure (governance model), the Cloud architecture and several recommendations for ensuring successful and efficient transformation from the currently used systems to a more advanced system.

1.4. Aims and Objectives

The main objective of this research is to investigate "the applicability" of a collaborative approach (community source) in LHE and make theoretical conclusions on

the basis of multiple case studies. Three case studies of public universities were used to model LHE institutes. The research also aims at providing meaningful insights into the collaborative (community source) approach with an emphasis on the Libyan context. This includes conclusions and suggestions that help decision-makers find the appropriate mechanisms to successfully implement this approach in LHE institutions, and overcome various obstacles to its application. In order to achieve the main objectives, the research also addressed the following sub-objectives:

- To compare alternative approaches to IS development in the context of LHE.
- To make an overview of the international experiences in this field, and to benefit from their expertise and experience.
- To develop an assessment framework that could:
    - Highlight the need for IS development in LHE.
    - Evaluate the experience of individual Libyan universities in the field of IS development.
    - Evaluate the level of advancement of the ISs implemented in Libyan universities.
    - Investigate obstacles that prevent the application of particular ISs in Libyan universities.
    - Identify the factors for the successful implementation of IS development in LHE.

1.5. Significance of the Research

The importance of the research stems from the fact that it deals with a contemporary topic in the literature on HE, namely the subject of the application of collaboratively developed ISs in LHE. The importance of this research is also highlighted in its focus on studying such an approach using Libyan universities as a model. Indeed, this study is a contribution to covering the gap in the research and literature on issues related to

- the current implementation of ISs in LHE at university-level,
- IS development, with an emphasis on LHE at university-level: assessing the readiness of Libyan universities to develop in-house applications
- Considering a collaborative approach to implementing an integrated IS within LHE at university level that can serve any LHE institute willing to participate, as well as the planners of LHE in the Ministry of Education.

This study is significant because only a small number of scholarly studies have been conducted on community-source systems in universities in general. To the author's knowledge, this is the first study to investigate the applicability of such an approach in LHE, using Libyan universities as a model, especially as this study is based on the analysis of multiple case studies.

1.6. The Delimitations of the Study

According to Simon, the delimitations of a study are those characteristics that limit the scope and define the boundaries of the study that lay within the researcher's control. The factors of delimitation include the choice of objectives, research questions, variables of interest, theoretical perspectives that the researcher adopts (as opposed to what could have been adopted), and the population that the researcher chooses to investigate (Simon, 2011). The author limited his investigation of the applicability of a collaborative approach to the following four directions:

Firstly, three public universities of differing characters were used to model LHE[1]. Although only three Libyan universities were studied directly in this research, information was gained indirectly about the ISs used in other universities.

Secondly, the ISs associated with business processes (educational activities, research activities, and other business activities) were only assessed in these three cases. These types of business activities are classified as in (Zornada & Velkavrh, 2005).

Thirdly, this research is conducted at a stage when "what is the current level of the system?" and "how should it be developed?" are specific matters of concern to the people who are directly involved in IS development. In other words, the opinions of end-users (ordinary staff or students) are not of direct importance at this stage. Indeed, their greatest concern is about the functionality of the system, rather than the system architecture itself. Hence, the functionality of the system is not a subject of interest in this research. Consequently, the author limited the study to persons who will be actively involved in the process of implementing new ISs.

Fourthly, three main factors were considered in the conceptual framework, namely: ERP, cloud computing and multi-tenancy. These three factors are compared with other technologies. In consequence, the focus of the research did not go beyond the scope of the overall goal.

1.7. The Theoretical Framework

The theoretical framework provides a scientific justification for a study and is considered to be a crucial component of a research project. Also, the theoretical framework grounds a study firmly in theoretical constructs (Adom, et al., 2018). In other words, it establishes a sense of structure that guides the researchers conducting the study. In practice, there are no fixed rules for structuring a theoretical framework, although it is necessary to create a logical structure. In this thesis, the theoretical framework relies on a descriptive analytical approach based on two foundations. The first foundation is a

[1] For more information about the philosophy of choosing universities to represent LHE indirectly, please check Section 3.2.1 in this research.

description of system development in general, with an emphasis on HE institutions, including collaborative approaches, as well as ERP-based systems. The author also provides a comparison between available solutions. This foundation is constructed by reading the literature related to the topic of research, with supportive observations from international projects.

The second method is illustrated in Figure 1, which represents the author's own work. Accordingly, the author examined 1) the Libyan side: in terms of IS performance, the capability to develop ISs, and other aspects of LHE at university level; and 2) the international side: in terms of how such ISs have been implemented and what can be learnt from these experiences. As a result, the outcome of this research is a set of recommendations regarding how LHE should develop new ISs (using Libyan universities as a model) and how they need to be equipped for this.

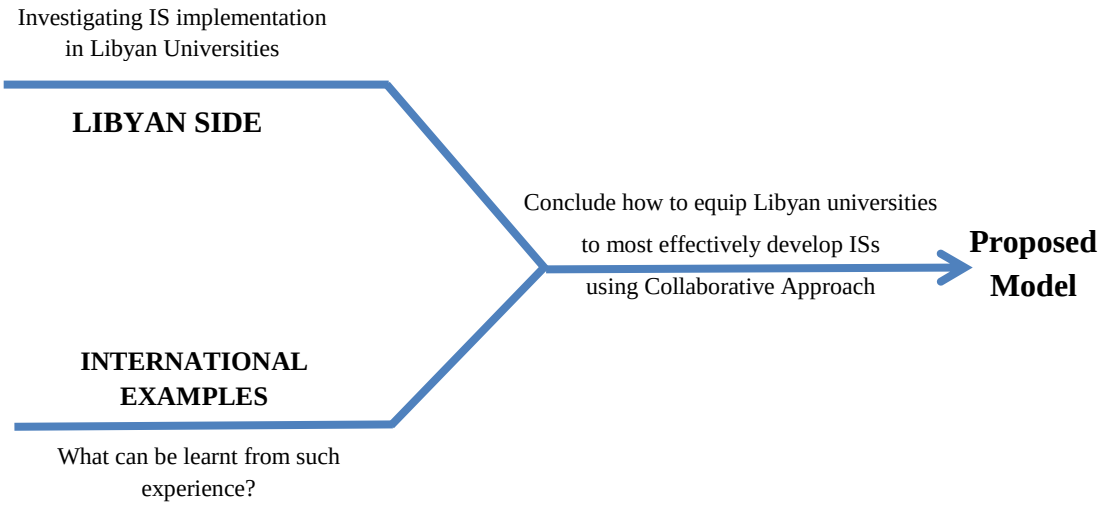


Figure 1: The research framework

1.8. The Master Plan of the Research Project

The master plan of the study is split into the following six phases, as shown in the Figure below:

Phase One: Theorization of the research topic. This was accomplished by a literature review of relevant areas, above all, classes of IT management systems. A review of the LHE system is also considered as the second source of this theorization. A comparison of different approaches was conducted.

Phase Two: In this phase, a short study on the international experiences of using collaboratively developed systems in university management was carried out. The author contacted representatives of the previously mentioned projects, to understand the experiences of implementing such systems, by sending written questionnaires. Due to the low number of responses, other data resources were included, such as a document review.

At the end of this phase, the author was able to define the variables and develop hypotheses.

Phase Three: An initial study was conducted on the first subject, University of Tripoli (UOT). This initial study guided the adaptation of the survey and interview for the other case studies, as well as determining whether or not to include more case studies of Libyan universities. The University of Tripoli was chosen as the subject of this initial study since the author is a staff member of this university and it is the leading university in Libya.

Phase Four: Further case studies were carried out in Libya. Initially, the number of cases studies was projected to be three, including the initial one. After conducting the initial study, the author had the option of deciding whether or not to include more case studies of Libyan universities. This phase was carried out through surveys, based on a semi-structured interview.

Phase Five: Based on the findings from the previous phases, the author formed a proposal for a consortium of Libyan universities (or LHE institutes). These recommendations include a proposed model for collaboration, the business model of the consortium, the consortium structure (governance model) and the Cloud architecture.

Phase Six: Conclusions based on the study's observations and findings, together with a description of the limitations of the study.

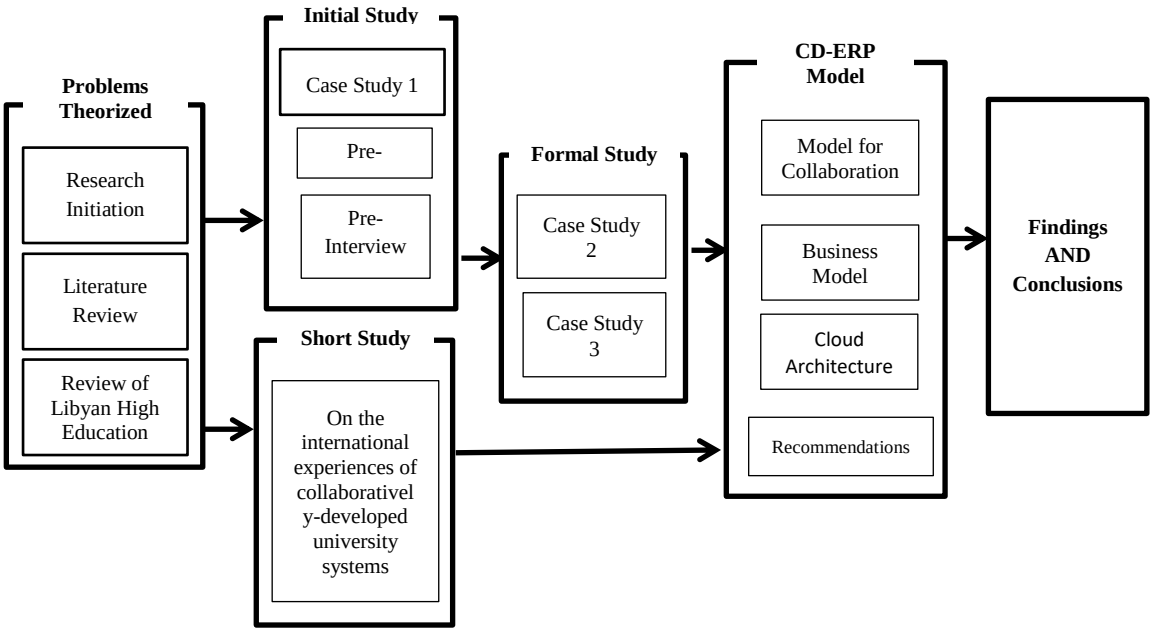


Figure 2: The master plan of the research project

1.9. Structure of the Research

This thesis is divided into eight chapters organized as follows: *Chapter One: Introduction*; An introductory chapter which introduces the basic concepts, such as the

statement of the problem, the purpose and objectives of the research, the significance of the research, and research boundaries; *Chapter Two: Conceptual Framework*; This chapter contains a review of the literature that is relevant to the research area of this study. Here, the author also provides a review on related topics, to give a wider background; *Chapter Three: The Methodology*; The methodological tools and methods used in the study are presented in this chapter, including research philosophy, strategy and approach, methods of data collection, and justifications for the choice of these methods; *Chapter Four: International Experiences*; A short description of the term "community-source" is provided, as well as cases of other projects which follow a similar approach; *Chapter Five: Hypotheses and Assessment Framework*: This chapter discusses the definition of the variables, presents the hypotheses, as well as the framework used to evaluate the level of ISs implemented in Libyan universities, including the models and techniques applied; *Chapter Six: Libyan Case Studies And Findings*: This chapter presents an overview of the subjects of the case studies and the findings from the fieldwork in Libya; *Chapter Seven: Analysis And Discussion*; An analysis and discussion of the findings from the case studies are presented, using the assessment framework; and finally, *Chapter Eight: Conclusions And Future Work*: Besides a discussion regarding the answers to the research questions, the limitations and contribution of this research, as well as future work, this chapter presents recommendations regarding the approach to IS development in Libyan universities.

1.10. Summary

This chapter has provided the basic concepts of the research: a statement of the problem, research questions, the purpose and objectives of the research, significance of the research and research boundaries. Furthermore, a short description of the concept of the CD-ERP model has been provided. Related studies have also been introduced. The structure of the thesis has been presented. The author has also discussed the master plan of the research, which was set at the beginning of the project. Some of these aspects will be presented in more detail in later chapters. The following chapter is the conceptual framework of this research. It deals with the review of literature that is relevant to the research area of this study.

CHAPTER TWO: CONCEPTUAL FRAMEWORK

2.1. Introduction

In the conceptual framework, a literature review on the research subject is provided. A conceptual framework represents the researcher's synthesis of a literature review in the process of explaining a phenomenon (Adom, et al., 2018). In principle, a literature review can be interpreted as a process or a product. The former involves a systematic examination of relevant prior works, to answer questions regarding theory, policy, and practice. The latter represents the new knowledge created from a harmonization of the literature reviewed. Also, a literature review is descriptive in nature (Bangert-Drowns, 2005) and helps scholars understand a research topic and its importance (Feak, et al., 2009). In this thesis, a narrative literature review was used to draw conclusions about the subject of the research area.

The topic of this research is quite new and very few related studies have been conducted. To the author's knowledge, this is the first academic research to be conducted on a community-source based model in the Libyan context. Due to this lack of research, the conceptual framework of the model that will be proposed on the basis of this study is constructed from its basic elements (the technologies and approaches adopted). In general, this research aimed to investigate the applicability of a collaborative approach to IS development in the LHE sector based on the technologies that are currently available. This approach is based on an analysis of the available technologies (e.g. ERP and Cloud Computing) and applicable management methods (e.g. collaborative approaches, Agile development).

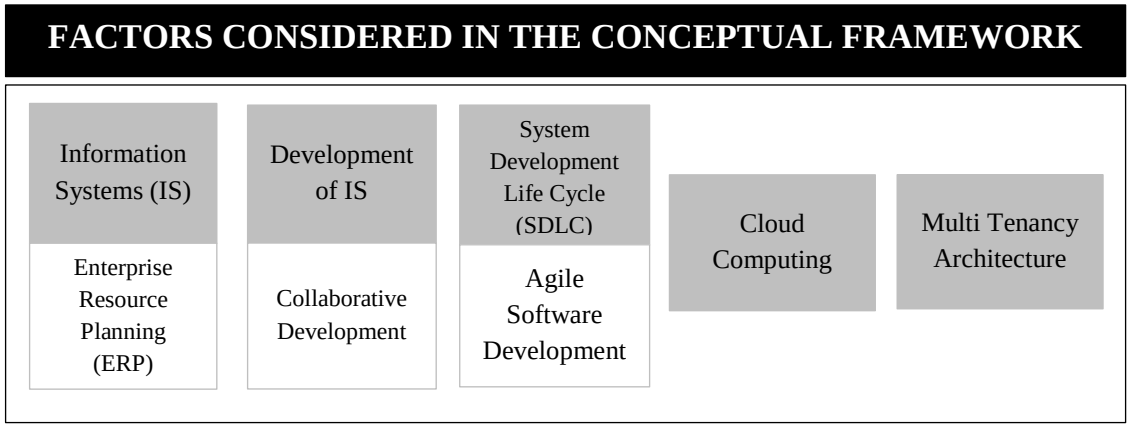


Figure 3: Factors considered in the conceptual framework used in the study.

As shown in Figure 3, there are five main areas covered in the conceptual framework. It first introduces types of ISs. Later, attention is paid to ERP systems, including a comparison to other possible solutions. IS development is then covered with an emphasis on a collaborative approach. The System Development Life Cycle (SDLC) is described as well, especially Agile practice. Both Cloud computing and multi-tenancy are also covered.

Besides this, a comparison with other available solutions is included, focusing on the advantages and disadvantages of the technologies and approaches considered. Other concepts and terms appearing in the thesis are also discussed.

2.2. Information Systems

2.2.1. Overview of Information Systems

The field of information systems (IS) has already become a major functional area of business (Anandkumar, 2017). Currently, ISs are found everywhere, aiding information creation and sharing within organizations, as well as between (Rainer & Cegielski, 2011). Indeed, IS plays a vital role in e-business and e-commerce operations, enterprise collaboration and management, and the strategic success of businesses, which are crucial in today's internetworked global environment (Anandkumar, 2017). Information technology (IT) architecture and infrastructure provide the basis for all ISs in an organization (Rainer & Cegielski, 2011). James and Marakas described IT as a very basic and crucial ingredient for any business to succeed in today's dynamic global environment (O'Brien & Marakas, 2011).

To begin with, what does the term "information system" (IS) mean? According to Reix and O'Brien, an IS can be defined as a group of people, procedures, and resources. These components are to obtain, transform, store and process information and distribute it within an organization. Moigne claimed that the term "IS" has been used in numerous ways and was historically connected to the use of computers in information management within an organization (Kamel, et al., 2012). Other researchers focus on two different ways of describing an IS as: the components that make up an information system and the role that these components play in an organization. An IS can be defined as a collection of hardware, software, and telecommunications that people build and use to collect, create, and distribute useful data, classically in organizational settings (Bourgeois, 2014). Anandkumar argued that an IS is a goal-directed teleological system in which the goals determine what information to consider and how informative objects should be nominated, labeled, described, organized and retrieved (Anandkumar, 2017).

2.2.2. Information Systems or Computer-Based Information Systems

Rainer and Cegielski claimed that the term "information system" is usually used synonymously with a "computer-based information system" since most of today's ISs are computerized, even though not all of them are (Rainer & Cegielski, 2011). The following question now arises: *Is there a difference between a computer-based information system (CIS) and an Information System (IS)?* Since many people confuse these two terms "Information System" and "Computer-Based Information System", the author intends to briefly consider here the similarities and differences between these two terms. Basically, a CIS is an IS that uses computer technology to complete some or all of its projected tasks.

Rainer and Cegielski defined an "IS" as a system to collect, process, store, analyze, and disseminate information for a specific purpose (Rainer & Cegielski, 2011). By combining these two definitions, we can say that a CIS is an IS that uses computer technology to collect, process, store, analyze, and disseminate information for a specific purpose.

Furthermore, O'Brien and Marakas stated that today most ISs are believed to involve computers. We have, however, been using ISs since the very beginning of civilization. Even some of the ISs regularly used today have nothing to do with computers (O'Brien & Marakas, 2011). Stair and George agreed that an IS can be a manual "IS" or computerized "CIS". They gave the example of some investment analysts who manually draw charts and trend lines to assist them in making investment decisions. They also defined a "CIS" as a set of hardware, software, databases, telecommunications, people, and procedures that are configured to collect, manipulate, store, and process data into information (Stair & Reynolds, 2010). In this research, the term IS is used to refer to any kind of IS, including CISs.

2.2.3. Components of Information Systems

Kamel et al. argued that it is hard to define the term IS without talking about the various components that constitute such a system. They also added that the definition of an IS differentiates between three components of an IS, namely: 1) Humans: Users and managers play the role of end-users to manage information, but they can also play a role in the strategic use of an IS; 2) Material: this refers to hardware (such as computers), software (such as operating systems and applications) and media (such as hard-disks). This material is used by people in the processing of information from its sources to its destination and the use of this information; and 3) Procedures: procedures can be described as a set of rules, management practices and the culture of business (Kamel, et al., 2012). Bourgeois argued that an IS is composed of the five following components: hardware, software, data, people, and processes. "Hardware, software and data" are the technical components, which are the first components that come to mind when talking about ISs, while "people and processes" differentiate the field of ISs from other technical fields like computer science (Bourgeois, 2014). To put it briefly, ISs are a combination of components/elements/resources that collect data "input", manipulate (process) these data, store and distribute (output) these data as information, to achieve the goals of an organization. Most researchers agree that "hardware, software, data, people, and processes" are the main components of an IS. Some consider additional components, such as procedures, policies, feedback mechanisms and databases (Stair & Reynolds, 2010) (Anandkumar, 2017).

2.2.4. Types of Information Systems

Electronic and mobile commerce, transaction processing, information management, and decision support are the most common types of ISs used in business organizations.

Some organizations have also employed what may be called “special-purpose systems”, such as virtual reality. Different types of ISs are meant to help organizations complete routine and specialized tasks. These systems are sometimes developed individually by an organization or delivered in an integrated form as one software package (Stair & Reynolds, 2010). Anandkumar chose to classify ISs into five types, namely: office information systems, transaction processing systems, management information systems, decision support systems (DSS), and expert systems (Anandkumar, 2017). On the other hand, O’Brien and Marakas argued that the ISs nowadays implemented in businesses worldwide can, theoretically, be classified in quite a few different ways. For example, ISs can be classified as either operations or management ISs. In this way, ISs are classified according to the major roles that each plays in the operations and management of a business (O’Brien & Marakas, 2011). Accordingly, ISs can be classified, on the basis of O’Brien and Marakas’s conceptual classification, as follows:

- **Operations ISs** that support business operations, this type includes: specialized processing systems, transaction processing systems, process control systems, and enterprise collaboration systems.
- **Management ISs** that support managerial decision making, this type includes: management ISs, decision support systems, and executive ISs.
- **Other types** can support operations and/or management applications, including: expert systems, knowledge management systems, strategic ISs, and functional business systems.

2.2.5. E-business

E-business is another important term that has to be clarified. Originally, the term “e-business – also known as e-solution” - was coined by Lou Gerstner, CEO of IBM. E-business is generally used to describe any form of electronic business that utilizes a computer. This definition is, in fact, outdated. Today, in most contexts, e-business refers exclusively to Internet businesses (Anandkumar, 2017). E-business is the use of the Internet and other network technologies to enable communication and collaboration, both within a networked enterprise and with its customers and business partners (O’Brien & Marakas, 2011).

2.2.6. The Phenomenon of Open Source

Software can be made available as open-source software or proprietary software (Xing, 2014). The former is software distributed under a licensing agreement in which the source code is shared, viewed and can be modified by other users or even organizations. Initially, open-source software was developed by a loose collaboration of volunteer programmers in which completed systems were later released to the public free of a licensing fee. Its definition was formulated in 1986, while the first version of a GNU (General Public License) was published in 1989 (Boulanger, 2005). In contrast,

proprietary software is created by one party (an individual or firm), who is the sole owner of the property rights (Singh, et al., 2015). Traditional proprietary systems are developed by a team and are sold or licensed to the public for a fee. Support for the software is usually provided by the developer (Singh, et al., 2015).

Open-source software can be further classified as community or commercial open-source. The rights to community open-source software are owned by a not-for-profit community, such that members generally do not derive direct revenue from this software, while commercial open-source software is owned by a vendor, who obtains revenue from this software (Xing, 2014). Both types of such projects involve software development by a team of paid programmers, and the system is provided either without charge (sometimes with the possibility of donation) or through fees and subscriptions (Boulanger, 2005). The quality of software depends on factors determining its usability, such as the ease of installation, documentation, user interface, the level of technical support, set of features, security and reliability (Xing, 2014).

Figure 4 summarizes the history of ISs over the past 70 years, from the very beginning of data processing during the 1950s and 1960s, to DSS during the 1970s and 1980s, to e-commerce and e-business during the 1990s and 2000s, all the way up to ERP and business intelligence at present. These classifications of ISs are, however, for convenience and emphasizing the different types of ISs. In the real world, ISs are naturally integrated combinations of several types of such ISs. Indeed, such systems are combined into integrated or cross-functional informational systems that provide a variety of functions, e.g. ERP systems (O'Brien & Marakas, 2011). With today's sophisticated technologies, it is challenging to classify any system as uniquely belonging to one of the types discussed above (Anandkumar, 2017). Many organizations are looking today to develop integrated systems that cross the boundaries of traditional business, to reengineer and improve vital business processes all across their environment. Developing integrated cross-functional enterprise systems is often a smart, or even necessary, move. Firms view the development of cross-functional enterprise systems as a strategic way of using IT to share information resources and improve the efficiency and effectiveness of business processes (O'Brien & Marakas, 2011). Even though some ISs[1] still operate as individual systems, organizations are increasingly combining their information needs into a single, integrated IS (Anandkumar, 2017).

[1] especially those with both operations and management aspects, such as expert systems

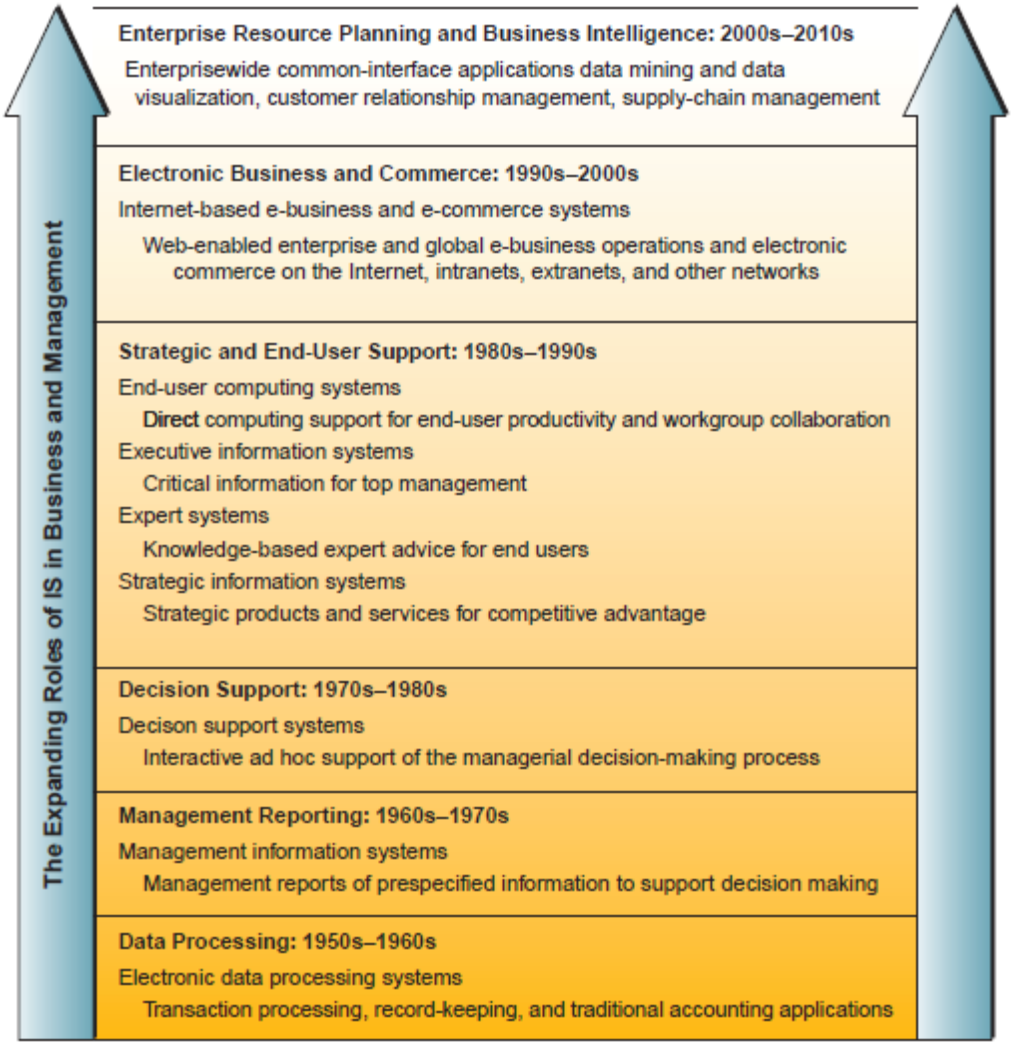


Figure 4: History of ISs – source: **(O'Brien & Marakas, 2011)**

2.3. Enterprise Resource Planning (ERP)

2.3.1. Overview of ERP

At the beginning of the IS era, ISs were independent. Rainer and Cegielski called this period the "age of information silos". These ISs or "information silos" did not communicate with each other. This disconnection between ISs inside a single environment made organizations less efficient. Rainer and Cegielski added that in business processes with more than one functional area, such inefficiency was noticeable. Consequently, ERP systems were developed to solve this problem. Such integration is the main objective of ERP systems (Rainer & Cegielski, 2011).

According to Gartner[1], ERP can be described as an IS application that brings financial, distribution, manufacturing, and other business functions into balance. It extends horizontally across the organization's business functions and vertically throughout the organization's supply chain. Bourgeois defined ERP as an IS application which uses a centralized database that can run the entire organization's activities. Bourgeois explained that IS application is a term that refers to how software was developed with the specific logic and rules behind its design, while the term "centralized database" means that data in an ERP system are stored in a single, central database. In fact, the centralization of the database is a powerful advantage of ERP systems, such that data entered in any department can be instantly available to other departments (Bourgeois, 2014). ERP does not only centralize the database of an organization, but also strengthens the processes that the organization adopts (Bourgeois, 2014). Certainly, ERP systems take an overall view of the business processes in an organization to integrate the planning, management, and use of all of an organization's resources, employing a common software platform and database. Such integration was described by Rainer and Cegielski as "tight", since it enables information to flow seamlessly across all functional areas. As they explained, the term "tight integration" means that any change in one functional area is instantly reflected in all other related functional areas (Rainer & Cegielski, 2011). ERP is a cross-functional enterprise system (ECS) driven by an integrated suite of modules that supports the basic internal business processes of an organization. As mentioned before, ECS are cross-functional ISs that improve communication, coordination, and collaboration between the members of business teams. Today, ERP is the technological backbone of e-businesses (Stair & Reynolds, 2010).

Since the emergence of ERP systems in the late 1990s, ERP systems have also become popular among practitioners and researchers. In global terms, the revenue from ERP software in 2011 was $253.7 billion. According to Gartner, this amount represents an increase of 7.5% compared to 2010. In the US market, a significant number of organizations have adopted ERP over the last two decades, and the revenue of the ERP market has grown from $17.2 billion in 1998 (O'Leary, 2000) to $39.7 billion in 2011 (Dover, 2012). Despite all the strengths of ERP, it possesses several problems and weaknesses. Arguments still exist as to whether the contributions of ERP to performance outweigh their shortcomings, since both the failure rate of implementation and the potential profits are high (Abugabah & Sanzogni, 2010). All of these advantages and disadvantages will be discussed in detail later.

[1] Gartner is a global firm involved in IT analytics.

2.3.2. A brief history of ERP

Historically, ERP systems evolved from what was called Materials Requirement Planning (MRP) systems developed during the 1970s. These systems aimed to ensure the efficiency of certain business functions, such as production planning, purchasing, and inventory control in manufacturing organizations (Stair & Reynolds, 2010). Hence, ERP systems were originally developed to facilitate processes in manufacturing businesses. Even though ERP systems were developed to integrate various functional areas, early ERP systems did not extend to certain functional areas of an organization, e.g. marketing, including customer relationship management (CRM), which would have enabled organizations to capture customer-specific information. In fact, early ERP systems were not even web-enabled (Rainer & Cegielski, 2011).

By the late 1980s and early 1990s, several organizations had reached the point where their legacy transaction processing systems led to weak integration. Such integration needed to be improved to coordinate activities and share valuable information across all the business functions of an organization. Consequently, costs were increasing and customer service was becoming poorer than desired. Large organizations, members of the Fortune 1000 list, were the first to take on the challenge of implementing ERP during the 1990s (Stair & Reynolds, 2010). ERP systems from this era are now called *ERP I*. In the course of this stage, ERP was criticized for its inflexibility. In fact, at that time, ERP vendors were asked to adopt more open, flexible, standards-based software architectures. Such reform was required by organizations implementing ERP to facilitate its integration with other applications (both their own and of cooperating organizations), as well as making it easier to make minor modifications to suit their business processes (O'Brien & Marakas, 2011).

Over time, ERP has been adapted into a more flexible form. ERP systems have gradually grown to include other functional areas of organizations and utilize the Internet. This development of ERP systems introduced what is now called *ERP II*. Rainer and Cegielski adopted the term "Inter-Organizational ERP Systems" to describe ERP II, while James and Marakas used the expression "Inter-Enterprise ERP Systems" (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011). In the literature, researchers may use different names to describe the ERP II stage, but they all agree that the growth of the Internet, intranets, and extranets encouraged ERP vendors to use Internet technologies to develop web interfaces and networking capabilities in their ERP suites (O'Brien & Marakas, 2011). These web-enabled ERP suites provide connections between organizations' key business systems and external stakeholders (Rainer & Cegielski, 2011). Besides, these features make ERP systems easier to use and connect to other internal applications (O'Brien & Marakas, 2011). ERP II systems were delivered as e-business packages or web-enabled suites. Such packages/suites were designed to integrate ERP, supply chain management (SCM), customer relationship management (CRM), decision support, portals, and other business functions**.** As a final note, by using ERP,

organizations are now able to operate many business processes using a single web-enabled suite (consisting of integrated software), rather than a variety of isolated e-business applications (Rainer & Cegielski, 2011).

2.3.3. Benefits of ERP

Best practice: Best practice involves adopting the most customer-friendly, efficient and effective practices. Effectiveness and customer orientation should be maximized for organizations to be competitive. ERP vendors have carried out extensive research to define the most efficient business processes. They have taken into consideration both 1) findings from scientific research groups and 2) the requirements of leading organizations from particular branches of industry. ERP modules were then designed to support best practice (Stair & Reynolds, 2010). As a consequence, ERP has best practice inbuilt. Consequently, when an organization implements ERP, it can also implement best practices**,** which results in substantial enhancements in the quality and efficiency of business processes (Bourgeois, 2014) (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011).

Better decision making: Improving the access to data for operational decision making is one of the primary benefits of implementing ERP, which delivers critical information on the performance of functional areas, thus resulting in improved decisions being made promptly (Stair & Reynolds, 2010) (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011)**.**

Tight integration: As stated previously, ERP is a system that ensures that information can be shared across all business functions and all levels of management inside an organization. As a result, any change in one functional area is instantly reflected in all other related functional areas. This way of functioning is described as "tight integration" (Rainer & Cegielski, 2011).

Decreased costs: After successful implementation of ERP, many organizations report significant reductions in costs compared to the previously used non-integrated legacy systems. This includes reduced transaction costs, as well as hardware and software costs (O'Brien & Marakas, 2011) (Rainer & Cegielski, 2011).

Elimination of inefficient or outdated systems: Adoption of an ERP system could lead an organization to replace several separate systems with a single, integrated set of applications for the entire organization. Stair and Reynolds see the problems of retaining old legacy systems as having two main aspects. Firstly, since they are poorly documented and the original developers are commonly not available, it is extremely difficult to repair/troubleshoot such systems. Besides, meeting the needs of new business/technologies via the adaptation of old systems is impractical (Stair & Reynolds, 2010).

Improvement in IT infrastructure or technological standardization: When organizations implement ERP, they consequently upgrade their IT infrastructure,

including hardware, operating systems, databases, etc. The previous IT infrastructure most likely came from a variety of vendors and suffered from a lack of integration between multiple hardware platforms, operating systems, and databases. Since implementing ERP involves standardizing technologies and fewer vendors, maintenance and training costs are expected to decrease (Stair & Reynolds, 2010).

Organizational flexibility and agility: As a result of tight integration, ERP systems enable organizations to be more flexible, agile, and adaptive. Organizations can, therefore, react quickly to changing business conditions. Besides, they benefit from new business opportunities (Rainer & Cegielski, 2011). More flexible organizational structures, managerial responsibilities, and work roles are expected, resulting in a more agile and adaptive organization and workforce. It thus becomes easier to capitalize on new business opportunities. However, this does not occur in all cases. Although efficiency enhancement is one of the most key strong points of an ERP system, the author has chosen to mention this advantage last, since it causes what is known as a loss of uniqueness. Losing uniqueness is one of the drawbacks behind the implementation of ERP (O'Brien & Marakas, 2011). This final point will lead to consideration of the drawbacks of ERP in the next section. Table **1** presents a summary of the benefits of ERP.

Table 1: Summary of the benefits of ERP – Source: author's own collection[1]

No.	Advantages	Possible challenges
1.	ERP has best practice built right into it	Similarities between the ERP modules implemented by different organizations (sometimes competitors) (Bourgeois, 2014) Customization as a solution to this problem (Stair & Reynolds, 2010) (Bourgeois, 2014)
2.	Tight integration	
3.	Organizational flexibility and agility	
4.	Better Decision support	
5.	Decreased costs	Not in all cases: several cases of costly failures of ERP implementation have been reported. (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011) (Zornada & Velkavrh, 2005)
6.	Lower level of IT support required	
7.	Elimination of inefficient or outdated systems	However, several organizations have some core systems that cannot be replaced with ERP modules, i.e. there exists a problem of integrating ERP with such systems (Stair & Reynolds, 2010).
8.	Improvement of work processes	

[1] References are given next to each point mentioned in the table.

9.	Technology standardization	

2.3.4. Drawbacks of ERP

There exists a high degree of risk in the implementation of ERP. The implementation of ERP has often been the reason behind projected schedules and budgets being overrun (Seo, 2013). The development strategy of ERP systems, as stated before, follows the principle of "best practice", as developed for the main business functions in the most successful organizations. A high degree of complexity and the need for adaptation to different organizations are expected to be involved in the implementation of ERP (Zornada & Velkavrh, 2005).

Complexity: The complex planning, development, and training required are some of the drawbacks of ERP implementation (Rainer & Cegielski, 2011)**.** There are two approaches to implementing ERP systems in an organization: Business Processes Reengineering (BPR) or ERP Customization (Seo, 2013). Both approaches are complex. Heavy customization can lead a system away from its original standards, which means that later upgrades or new system functionalities will then be difficult to implement. Some organizations simply end up adapting their environments to the system rather than the other way around. This is known as the "power of default" (Pollock & Cornford, 2004). Rainer and Cegielski suggested that to avoid this problem, top management should involve affected employees in the planning and development phases and also in changing management processes. Besides, an organization must not try to do too much, too quickly in the conversion process (Rainer & Cegielski, 2011).

A loss of uniqueness: Although the implementation of ERP is expected to lead to efficiency enhancements, similar ERP systems based on a variety of modules will be utilized by different competitors. This means that many organizations will simply find themselves becoming more like their competitors, which makes it much more difficult to differentiate themselves (Bourgeois, 2014). This usually leads to what is known as a loss of uniqueness. Losing uniqueness is one of the drawbacks of ERP. Bourgeois mentioned that customization is a possible solution to the uniqueness issue (Bourgeois, 2014). In reality, ERP systems are not limited to large Fortune 1000 companies. Small and Medium-Size Enterprises, SMEs, both for-profit and not-for-profit organizations, such as public universities in Libya, can achieve real business benefits from implementing ERP. In the real world, several SMEs have chosen to implement so-called *open-source ERP* systems. Open source ERP systems can be modified to customize ERP modules to meet an organization's needs. Such systems are much less costly to acquire and are relatively easy to modify to meet a business's needs (Stair & Reynolds, 2010). However, customization comes with a cost.

Difficulties involving customization: Organizations following the approach of customization are required to customize processes to their ERP system whenever an

update of the system comes out. This involves the maintenance of changes and retests of the system. Instead, an organization might only customize processes that are critical to its competitive advantage (Bourgeois, 2014). Also, over-reliance on heavy customization could cause the implementation of ERP to fail (Noaman & Ahmed, 2015).

Changes in existing business processes: ERP vendors developed ERP modules based on the best practice of predefined business processes. To adapt to the predefined business processes of ERP, organizations may decide to change their existing business processes as an approach to implementing an ERP system, rather than customizing the ERP system to their practices. This is a complex and risky task, especially in organizations with well-established procedures (Rainer & Cegielski, 2011). In simple terms, the so-called "best practice" is sometimes not adaptable to a particular organization and efforts to introduce such practice might cause great disruptions in the workplace (Stair & Reynolds, 2010). In some cases, such changes may be seen by long-time employees as being so drastic that they retire or quit, rather than accept the changes (Stair & Reynolds, 2010).

Costs: Several cases of costly failures of ERP implementation have been reported. When core business processes and ISs fail, huge losses in revenue, profits, and market share can occur. For instance, Hershey Foods, Nike, A-DEC, Connecticut General and FoxMeyer Drugs lost amounts involving hundreds of millions of dollars. Above, the author has presented a large number of reasons behind ERP failure, which are closely related to underestimating the complexity of the planning, development, and training required to implement a new ERP system, e.g: by not involving affected employees in the planning and development phases and in changing management processes; trying to do too much too fast in the conversion process; insufficient training; and failing to perform appropriate data conversion and testing in the new system (Rainer & Cegielski, 2011). O'Brien and Marakas also mention that the costs and risks of failure involved in implementing a new ERP system are substantial. A sizeable minority of organizations experienced noticeable and costly failures that heavily damaged their overall business, although they eventually successfully implemented ERP (O'Brien & Marakas, 2011). Although ERP offers many strategic advantages, it takes time and money to obtain the full benefits of ERP (Stair & Reynolds, 2010). As described later in Section 2.3.7, some authors see delays as being beneficial in HE. Unlike in other disciplines, such delays may be perceived in HE as giving more time for additional training and relieving the pressure on the staff using the new system (Fisher, 2006).

Risks inherent in utilizing ERP modules supplied by one vendor: In some cases, ERP vendors design their modules to eventually become outdated or ERP modules no longer meet a business's needs. In such cases, it would be highly costly and risky to switch to another ERP vendor (Stair & Reynolds, 2010). Also, some ERP vendors could merge or simply shut down their businesses. According to Gartner, the consolidation of vendors and the return to basic business operations has had a crucial influence on the implementation of ERP in the HE environment. Based on the literature, Oracle, SCT,

PeopleSoft, SAP, Jenzabar, and Datatel are the major ERP vendors for HE worldwide. According to research carried out by the ECAR organization, it is noticeable that none of these vendors is a market leader (Zornada & Velkavrh, 2005). Hence, it is much harder to choose between these vendors. Stair and Reynolds, however, suggested that choosing the right long-term business partner is the best solution to this problem. Indeed, selecting an ERP system does not only involve choosing the best software product (Stair & Reynolds, 2010).

Difficulties involving the integration of ERP with core legacy systems that cannot be replaced: Several organizations have some core systems that cannot be replaced by ERP modules. In some cases, organizations have even chosen to run selected ERP modules rather than a full suite, so that they could keep on using some of their old systems. Stair and Reynolds mentioned the difficulties experienced by firms when making other systems operate alongside their ERP systems. Some firms have even been forced to develop or purchase additional software to create bridges between their legacy systems and ERP modules (Stair & Reynolds, 2010). Table 2 presents a summary of the drawbacks of ERP.

Table 2: Summary of the drawbacks of ERP - Source: author's own collection[1]

No.	Disadvantages	Possible Solutions
1.	Similarities between ERP modules implemented by different organizations (sometimes competitors) (Bourgeois, 2014)	Customization, including so-called open source ERP systems that can be modified to customize ERP modules to meet the needs of a firm. Such systems are much less costly to acquire and are relatively easy to modify to meet business needs (Stair & Reynolds, 2010) (Bourgeois, 2014)
2.	Loss of uniqueness (Bourgeois, 2014)	Customization (Bourgeois, 2014)
3.	Difficulties of customization (when organizations have to maintain the changes themselves) (Bourgeois, 2014)	Customizing only processes that are critical to the competitive advantage of the organization. (Bourgeois, 2014)
4.	Implementation of ERP system requires changes in existing business processes	Customization (Bourgeois, 2014) (Stair & Reynolds, 2010)
5.	Complexity: the complex planning, development, and training required (Rainer & Cegielski, 2011).	Involving affected employees in the planning and development phases and in the processes of managing change (Rainer & Cegielski, 2011).
6.	Expensive and time-consuming to implement. In general, the risks involved in implementing a new ERP system are significant (Rainer & Cegielski, 2011).	As well as involving affected employees in the development phases, the organization must not try to do too much too fast in the conversion process (Rainer & Cegielski, 2011).
7.	Difficulties involved in integrating ERP systems with core legacy systems that cannot be replaced	Develop or purchase additional software to create bridges between these systems and ERP modules (Stair & Reynolds, 2010)
8.	Risks involved in utilizing ERP modules supplied by one vendor	Choosing the right long-term business partner: selecting an ERP system does not only involve choosing the best software product.

[1] References are given next to each point mentioned in the table.

9.	Risks of implementing ERP	Run appropriate planning, development, and training (Rainer & Cegielski, 2011) (Zornada & Velkavrh, 2005) (Rani, 2016)
10.	Costs: the costs and risks of failure involved in implementing a new ERP system are substantial. (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011) (Zornada & Velkavrh, 2005)	Run appropriate planning, development, and training (Rainer & Cegielski, 2011) (Zornada & Velkavrh, 2005) (Rani, 2016)
11.	Expensive and time-consuming to implement (Rainer & Cegielski, 2011)	Run appropriate planning, development, and training (Rainer & Cegielski, 2011) (Zornada & Velkavrh, 2005) (Rani, 2016)

2.3.5. Unsuccessful implementation of ERP

Due to the disadvantages mentioned above and other factors, the implementation of ERP is challenging for organizations. It requires great amounts of resources, the best IS and business staff, and plenty of management support (Stair & Reynolds, 2010). Hence, the implementation of ERP might fail. The literature presents several reasons for the unsuccessful implementation of ERP. These are summarized in Table 3.

Table 3: Summary of factors leading to unsuccessful ERP implementation - Source: author's own collection[1]

No.	Failure factors	Type
1.	Underestimation of the planning and development required (Rainer & Cegielski, 2011) or inadequate/inappropriate adoption (Noaman & Ahmed, 2015) (Abugabah & Sanzogni, 2010)	Managerial
2.	Not involving affected employees (Rainer & Cegielski, 2011) (Rani, 2016)	Managerial
3.	Adopting a too fast conversion process (Rainer & Cegielski, 2011) (Rani, 2016) or too tight project schedule (Noaman & Ahmed, 2015). Incomplete participation from the users (Rani, 2016). Not selecting the project team from among the most experienced and trustworthy professionals (Zornada & Velkavrh, 2005). Failure to get user support and ineffective communication with users (Seo, 2013)	Managerial
4.	Lack of appropriate ERP integration (Noaman & Ahmed, 2015).	Managerial
5.	High turnover rate of project team members (Noaman & Ahmed, 2015).	Managerial
6.	Ineffective consultants (Noaman & Ahmed, 2015).	Managerial
7.	Low effectiveness of project management (Noaman & Ahmed, 2015) Lack of commitment from senior managers and a lack of an effective methodology for project management (Seo, 2013)	Managerial
8.	Low quality of Business Process Reengineering (BPR), in the case of choosing this approach instead of customization, (Noaman & Ahmed, 2015) or failure to redesign business processes. (Seo, 2013)	Managerial
9.	Unclear concept of the nature and use of an ERP system from the users' perspective (Noaman & Ahmed, 2015)	Managerial

[1] References are given next to each point mentioned in the table.

10.	Unrealistic expectations from top management concerning an ERP system. (Noaman & Ahmed, 2015)	Managerial
11.	Poor training of users: for instance, staff training is a very important process when implementing ERP in any field, including higher education, to reap the benefits from these systems (Rani, 2016). Inappropriate education of employees, who are thus unable to satisfactorily manage the system (Zornada & Velkavrh, 2005). Insufficient training of end-users (Seo, 2013)	Managerial
12.	Poor knowledge transfer (Noaman & Ahmed, 2015)	Managerial
13.	The organization is not ready for the changes brought about by an integrated information system (Zornada & Velkavrh, 2005)	Managerial
14.	Misunderstanding of the changes required (Seo, 2013)	Managerial
15.	Strategic targets are not clearly defined. An ERP system was and still is the only possible way of reaching ambitious targets, because it comprises both an overall view on business operations and a common database for data and transactions. (Zornada & Velkavrh, 2005)	Managerial
16.	Conflicts between departments of users (Stair & Reynolds, 2010)	Managerial
17.	Composition of the project team (Seo, 2013)	Managerial
18.	Over-reliance by IT professionals on the claims of ERP vendors. (O'Brien & Marakas, 2011)	Technical
19.	Over-reliance on heavy customization. (Noaman & Ahmed, 2015)	Technical
20.	Poor IT infrastructure. (Noaman & Ahmed, 2015)	Technical
21.	Low quality of testing. (Noaman & Ahmed, 2015)	Technical
22.	ERPs are difficult to learn and use with a complicated user interface. (Rani, 2016)	Technical
23.	Attempts to build bridges to legacy applications (Seo, 2013). Some core legacy systems are crucial to the organization and cannot be replaced. As a result, organizations are forced to develop or purchase additional software to create bridges between these systems and ERP modules (Stair & Reynolds, 2010)	Technical

2.3.6. ERP in Higher Education (HE)

The spread of information and communication technology (ICT) and increased demand for computing has led to the growing popularity of ICT solutions in all disciplines, including higher education (HE) and its institutes (Rani, 2016). There have been calls worldwide for public universities to improve their performance and efficiency as non-profit institutions supported by national governments. At the same time, public universities face decreasing governmental support. Other challenges facing universities, including the increasing expectations of stakeholders, such as students and governments, meeting quality and performance standards, and maintaining a competitive level of education, have pressured universities into adopting new ICT strategies (Abugabah & Sanzogni, 2010).

Even considering these difficulties and risks, the last decade has seen a remarkable worldwide expansion of ERP systems into HE. Without a doubt, ERP systems have played a substantial role in the development of IT in HE (Noaman & Ahmed, 2015). According to Rani, ERP systems are the most complex software applications adopted by universities and are accompanied by significant investments in their implementation (Rani, 2016). HE institutes are reported to have spent more than $5 billion on investments in ERP during the last few years (Seo, 2013). This investment represents the biggest investment in ICT for HE institutes. Zornada and Velkavrh added that ERP systems are a step closer, but still

not adapted to supporting business activities in HE institutes (Zornada & Velkavrh, 2005). Moreover, Noaman and Ahmed argue that a substantial part of the role that ERP has played in HE institutes is unrelated to the core disciplines of HE (Noaman & Ahmed, 2015).

Initially, other disciplines, such as manufacturing or corporate enterprises, perceived the opportunities for making profits from ICT, including the implementation of ERP. Later, the HE sector and its institutions perceived these opportunities. Nowadays, the HE sector and its institutions are paying attention to the opportunities resulting from ERP, not only for educational and research activities, but also from a business point of view, since ERP supports, e.g. administrative, organizational and accounting functions (Rani, 2016). At the same time, HE has always been a sector that has its unique characteristics, core processes and objectives compared to other disciplines (corporations, sectors) (Noaman & Ahmed, 2015). Universities are organizations that have a high rate of data flow between its processes and stakeholders including students, teachers, suppliers, competitors and employees (Awad, 2014). For instance, the academic activities supported in HE start from such basic processes as scheduling and end in more advanced processes, such as e-advice for students (Noaman & Ahmed, 2015).

Many similarities between ERP implementation in educational organizations and other businesses have been identified in previous studies (Pollock & Cornford, 2005). The consequences of implementing ERP in HE should be studied more fully, to address the role of ERP in changing educational organizations and compare the results of its use with those obtained in similar organizational cultures (Noaman & Ahmed, 2015).

On the other hand, according to a UNESCO report, ERP vendors are increasingly seeing the education market as a profitable "market", possibly worth several hundred billion dollars in revenue. The term "*commercializing higher education*" has been growing in popularity, indicating that scientific and teaching bodies have become "big business" and universities have to invest heavily just to maintain their position (Meek, et al., 2009). Seo used this term, as universities have been forced to admit that "education is a business and students are the customers" (Seo, 2013). ERP vendors are also aware of the fact that an increasing number of HE institutes have introduced ERP systems. Hence, their solutions have already been expanded, to satisfy the needs of HE institutes (Rani, 2016).

As mentioned previously, the implementation of ERP has a high failure rate and debate still exists concerning the overall contribution of ERP to performance, since both the failure rate of implementation and the possible profits are high (Abugabah & Sanzogni, 2010). A large number of studies of ERP systems in various sectors have been conducted, especially in the last decade. ERP implementation and several related issues have begun to attract the attention of researchers. Nonetheless, research about ERP systems in the HE sector is still in its early stages, although most of these studies have discussed many important issues in detail - even those related to selecting a vendor and the implementation team (Rani, 2016) (Abugabah & Sanzogni, 2010). Nielsen also confirmed that very little

research has been conducted on implementing ERP in HE compared to other environments (Nielsen, 2002). Abugabah and his team added that, because of this, little attention has been paid to ERP implementation in HE, or the potential of ERP systems to improve overall efficiency and business efficacy in organizations. The effectiveness of ERP in HE remains unclear, which indicates that investigations into whether or not ERP systems deliver sustainable outcomes remain essential (Abugabah & Sanzogni, 2010).

In this section, the author will briefly discuss several studies conducted on the implementation of ERP in HE. The difficulties and high failure rate in implementing ERP systems in HE environments have been cited in the literature (Rabaa'i, 2009). Some of these studies showed that 50% of the implementations of ERP in HE institutes went over their budgets and did not meet the scheduled deadline (Abugabah & Sanzogni, 2010). This is generally consistent with failure rates for ERP projects in other sectors, which are often reported as ranging between 50% and 70% (Saxena & McDonagh, 2019). It is also noticeable that the failure rate in HE is at the lower end of this range. In those institutes where ERP systems have been applied, only 30% have successfully employed them in an effective manner (Awad, 2014). Recent research claimed that as many as 60% to 80% of these failures were due to not achieving the expected outcomes and/or a lack of improvement in performance, as well as users expressing dissatisfaction with the performance of their ERP system (Abugabah & Sanzogni, 2010).

As mentioned before, ERP was initially designed for manufacturing organizations, and ERP vendors later provided special suites for HE. However, HE is a unique environment and the approach of best practice in manufacturing may not be fully applicable in such an environment, even with the use of packages adapted to HE. Thus, the approaches of customization or Business Processes Reengineering (BPR) have been designed to solve the problem of compatibility. Although ERP provides numerous options for customization, these options may increase the risk of failure by increasing the scope of work and cost of implementation, as well as causing delays in implementation schedules. Seo added that by using customization it becomes hard to achieve the full benefits offered by ERP (Seo, 2013).

1) Benefits of ERP that are exclusive to HE

Most of the benefits of ERP in other disciplines are similar to the ones reported in the HE environment, including: (1) improved access to information for planning and managing an institution, (2) improved services for the faculty, students and staff, (3) lower levels of business risk, and (4) increased income and decreased expenses, due to improved efficiency (Seo, 2013). However, Zornada and Velkavrh argued that the integration of all of the business functions in HE could be of key importance behind implementing ERP in such an environment. Such integration represents a combination of systems for student administration, human resource management systems, financial systems, and other operations that used to be supported by separate and often incompatible legacy systems

(Zornada & Velkavrh, 2005)**.** These legacy systems did not communicate with each other and led to duplicating resources and services (Seo, 2013). Indeed, the implementation of an integrated database shared by different departments and, consequently, different business modules of a single integral IS solution is of key importance. Using such an integrated IS solution, data will be transferred between departments instantly. Advanced technology, such as web technologies, mobile phones, and online solutions, can also be used (Zornada & Velkavrh, 2005)**.** The central repository where data are stored can give universities easy and up-to-date access to users, not only to the administrative sections within an organization, but to people who constantly interact with the organization, such as faculty, students, and staff (Seo, 2013).

2) Drawbacks of ERP that are exclusive to HE

As mentioned previously, the implementation of ERP systems in HE and its institutes is often described as extremely difficult (Abugabah & Sanzogni, 2010). The high cost of ERP, the difficulties of its planning, implementation, customization, and configuration are the main reasons for the unsuccessful implementation of ERP in other disciplines, just as in the HE environment. Since ERP was originally designed for businesses, Rani claimed that the difficulties in implementing ERP are relatively prominent in HE institutes, as they form part of the non-profit sector and are supported by governments. This is particularly characteristic of public universities (Rani, 2016). Again, the unique characteristics of HE interfere with the implementation of ERP. The term "*commercializing higher education*", which means "treating education as a business and students as customers", could make the resistance to implementing ERP in universities much greater, because it involves not merely the adoption of a new IS, but a holistic change in the organizational culture. The administrative and academic sections are two sources of authority within a university. Both types of authority will fear losing control to the other side. Also, universities do not always have management or IT staff who are well-versed in organizational functions (Pollock & Cornford, 2005).

3) ERP Support for HE

Internationally, the major ERP vendors in HE are Campus Management, Datatel, Jenzabar, Oracle, PeopleSoft, SAP, and SunGard SCT. In the Middle East and North Africa, most of the major ERP systems, such as Oracle and SAP, have developed Arabic interfaces and solutions for the local market (Technical Report, 2017). Student lifecycle management software from ORACLE and SAP is one example of such an ERP module for HE (Seo, 2013). As stated before, ERP systems consist of a variety of integrated modules, including modules for manufacturing, distribution and sales, accounting, and human resource applications (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011). Several modules have been adapted to the special characteristics of HE, as described below:

- Core ERP modules (financial management, operations management, and human resource management) (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011)
- Extended ERP modules (customer relationship management, supply chain management, business intelligence, and e-business) (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011)
- ERP modules for academic support services such as 1) student administration (enrolment procedures and student enrolment, financial support for students, student data) (Zornada & Velkavrh, 2005)
- ERP modules may include more specialized modules, such as alumni and promotion tracks, as well as the management of grants (Technical Report, 2017).

2.3.7. Should an ERP Approach be Adopted?

As mentioned previously, some authors have described the costs and risks involved in the implementation of ERP in any environment as high, whereas the return on investments is medium to long-term. Concerning HE, although there are similarities between HE institutes, such as universities, and other kinds of organizations, Pollock and Cornford argue that the implementation of ERP creates tension and affects the identity of universities, thus creating new organizational issues based on the perceived uniqueness of specific universities (Pollock & Cornford, 2004) (Seo, 2013). The following question arises here: "*Is it better not to follow an ERP approach in HE?"* Zornada and Velkavrh cited the answer given by the chief information officer (CIO) at George Washington University, "*certainly NOT".* He argued that students will, sooner or later, demand services, offered in other places via ERP solutions (Zornada & Velkavrh, 2005). Another answer was given by Shirley Payne, Director of Strategic Studies at the University of Virginia: "It is truly remarkable how rapidly institutes have signed on to a strategy that requires such a large and focused effort to implement successfully" (Technical Report, 2017). Both answers are true, since it is a fact that universities cannot run away forever from adopting these demanding, yet successful, technologies.

As a final point to conclude this short discussion, almost all of the studies conducted on the implementation of ERP showed that the ERP software itself is rarely the source of failure (Noaman & Ahmed, 2015). This is confirmed by other studies, such as (Scott & Vessey, 2000; Helo et al., 2008; Maditinos, Chatzoudes & Tsairidis, 2012), where it was found that the failure of the implementation of ERP was not caused by the ERP software itself, but rather by the complexity of the massive changes caused by the adoption of ERP in organizations (Seo, 2013). Helo et al., (2008) explained that ERP systems are not like other ISs in terms of the problems of implementation. These problems are not even technologically related issues, such as technical complexity or compatibility, but in most cases are organizational and human-related issues. They provide some examples of such organizational and human-related problems, including: resistance to change, organizational culture, incompatible business processes, project mismanagement and lack

of commitment from top management (Seo, 2013). Zornada and Velkavrh explain that these failures can be explained by the fact that the implementation of ERP has forced organizations to follow the principle of 'best practice', as seen in the most successful organizations, which form appropriate reference models (Zornada & Velkavrh, 2005). Also, Seo sees that public universities are under pressure from both the government and the public, specifically in the form of decreasing government funding and increasing expectations from stakeholders. Hence, ERP systems can be very appealing to HE institutes as a potential route to meeting the criteria for achieving greater integration in their management systems (Seo, 2013).

Another argument is that overrunning the deadline for implementation could be seen as a benefit in HE. Fisher ran a study to examine the perceptions of staff regarding the implementation of ERP in three Australian universities. This study indicates that overrunning the deadline for implementation is associated with a more positive perception. Unlike other disciplines, in HE, such delays may be perceived as giving more time for additional training and relieving the pressure on the staff using the new system (Fisher, 2006). Abbas added that the role of top management is critical to handling the reengineering of business processes in universities. Such environments, as we discussed before, are very resistant to change. Hence, top management should ensure that employees are informed and involved in the implementation process and progress (Abbas, 2011). Abbas's study confirmed what was stated by Al-Sehali ten years before. According to a literature review by Al-Sehali, the support of top management was one of the most frequently cited as being a critical factor of the success of ERP implementation (Al-Sehali, 2000).

During the progress of this research, the author noted that out of the 23 cited factors of failure, 17 are related to managerial aspects[1]. Besides, all of the technical factors listed, apart from the one given by (Rani, 2016), "*ERP are difficult to learn and use, with a complicated user interface*",- are not directly related to ERP systems themselves. This confirms the view that the ERP software does not itself cause unsuccessful implementation.

2.3.8. Critical Success Factors for the Implementation of ERP in HE

The author has selected CSFs for successful ERP implementation based on: (1) CSFs faced both by various kinds of organizations and those that are specific to the HE field during the implementation of an IS, (2) based on the author's literature review concerning ERP systems, including the advantages, disadvantages and reasons for unsuccessful implementation of such systems, and finally (3) the Libyan context, based on the literature review, fieldwork in Libya and the author's own experience. Again, most CSFs are related

[1] For more detail, refer to Table 3.

to managerial aspects rather than technical ones. The selected CSFs are classified by factor type in Table 4.

Table 4: Summary of critical success factors (CSFs), classified by factor type - Source: author's own collection[1]

No.	Factor	Type
1.	*Commitment and support from top management*: this factor is one of the most commonly observed CSFs in the literature on ERP implementation. (Rabaa'i, 2009) (Shatat, 2015) (Villari & Jharkharia, 2015) (Abugabah & Sanzogni, 2010) (Rani, 2016) (Seo, 2013) (Rabaa'i, 2009)	Managerial
2.	*Management of change*: the implementation team should prepare a formal program for managing change (Rabaa'i, 2009) (Villari & Jharkharia, 2015) (Abugabah & Sanzogni, 2010) (Rani, 2016)	Managerial
3.	*Project management*: careful project management is required in ERP (Villari & Jharkharia, 2015) (Rabaa'i, 2009)	Managerial
4.	*ERP adapted to a Business's Processes*: if there is a match between the practices followed in the organization and the processes adopted by ERP, ERP will quickly be assimilated into the system (Rabaa'i, 2009) (Seo, 2013). Also, customization should be avoided, or at least minimized as much as possible, to achieve the full benefits of an ERP system (Rabaa'i, 2009) (Villari & Jharkharia, 2015)	Managerial
5.	*Training and Education*: a large number of researchers have stressed the need to include training as a critical aspect of ERP, while others generally mentioned the need for training (Rabaa'i, 2009) (Villari & Jharkharia, 2015)	Managerial
6.	*Ensuring the participation and involvement of the 'employees' affected by the implementation of ERP*. (Rani, 2016) (Shatat, 2015) (Shatat, 2015) (Villari & Jharkharia, 2015) (Rainer & Cegielski, 2011) (Seo, 2013)	Managerial
7.	*Communication*: Effective and efficient communication between completely different groups of people (e.g. the management of a HE institute and IT experts) increases the likelihood of successful ERP implementation, (Zornada & Velkavrh, 2005) (Rani, 2016) (Villari & Jharkharia, 2015) Rabaa'i, 2009) (Seo, 2013)	Managerial
8.	*ERP teamwork and composition of the team*: The project team must be selected from among the most experienced and trustworthy professionals. The ERP implementation team should consist of representatives from all functional units of the organization, from technical experts to senior executives. (Rabaa'i, 2009) (Shatat, 2015) (Villari & Jharkharia, 2015)	Managerial
9.	*Strategic IT planning, vision, clear goals, and objectives*: The requirements and objectives of the project, together with a clear vision and a comprehensive project plan should be developed to be compatible with the goals of an organization to ensure the success of ERP implementation. (Rabaa'i, 2009) (Shatat, 2015) (Villari & Jharkharia, 2015)	Managerial
10.	*Selection of and relationship with consultants*: (Rabaa'i, 2009) (Villari & Jharkharia, 2015)	Managerial
11.	*Cultural Factors*: This is related to the type of the organization, its processes and style, and how decisions are made. (Villari & Jharkharia, 2015) (Abugabah & Sanzogni, 2010) (Rani, 2016) **(Seo, 2013).** For HE**,** the ability of ERP systems to support business processes in universities should be ensured. (Abugabah & Sanzogni, 2010)	Managerial

[1] References are given next to each point mentioned in the table.

12.	*Selection of an ERP system and the choice of ERP architecture*. (Rabaa'i, 2009) (Villari & Jharkharia, 2015)	Technical
13.	*Selection of a vendor and customer support*: the factors to be considered include the vendor's reputation, core business area, financial strength, customer support offered, technical strength and capabilities, mission and vision (Villari & Jharkharia, 2015)	Technical
14.	*ERP system integration*: appropriate ERP integration should be taken into consideration (Rabaa'i, 2009) (Noaman & Ahmed, 2015). ERP compatibility with the legacy system(s) must be considered (Villari & Jharkharia, 2015) (Abugabah & Sanzogni, 2010)	Technical
15.	*The level of existing technology/infrastructure* (Villari & Jharkharia, 2015)	Technical
16.	*Software development, testing, troubleshooting* (Villari & Jharkharia, 2015)	Technical
17.	*Post-implementation evaluation*: Monitoring and evaluation of performance (Rabaa'i, 2009) (Shatat, 2015) (Villari & Jharkharia, 2015) (Abugabah & Sanzogni, 2010)	Technical

2.4. Development of Information Systems

Issues of systems development play a central role in the IS field. It has certainly been prescribed in the journey towards successful ISs. There are numerous views on IS development, as software development involves various risks and uncertainties (Rocha, et al., 2011). Since IS development relies heavily on the knowledge and creativity of individual software developers and their intense interactions, it presents new research challenges as well. Many authors argue that successful IS development is most likely to be achieved by the adoption of a formalized system of development methodologies. However, some developers have rejected the implementation of methodologies in practice. There are possible reasons behind such rejection, including: following methodologies has resulted in low productivity, methodologies often lack contingency/emergency plans, methodologies have in many cases turned out to be too inflexible to allow requirements to be changed and inappropriate for solving given issues in a particular situation. Only a few methodologies critically address important social, political and organizational dimensions of development. However, methodologies remain influential and new ones are being designed (Stolterman, et al., 1996). Galviņa and Šmite's findings showed that there is no universal development methodology appropriate for all projects and organizations. Each organization has to choose the most appropriate one for their situation (Galviņa & Šmite, 2011).

At the same time, the development of software is no longer confined to an individual developer, but has to rely on distributed cognition by reaching into a networked world of information and computer-mediated collaboration (Ye, 2006). Indeed, IS development is an intensely collaborative process where success depends on the ability to create, share and integrate information (Lanubile, 2009). The management of project integration in distributed environments is mainly affected by the fact that each organization (or department) often has its standards and processes, but there are no standards to determine how various organizations (or departments) should combine them or work together. This is expected to be less problematic in the case of organizations with fairly uniform working

environments, such as higher education (HE) institutes in Libya, where this new model is being proposed (Galviņa & Šmite, 2011).

To understand the proposed model, some terms must be defined first. The approach of the collaborative development model is a hybrid one that cannot be described clearly without speaking in these terms. Even though this approach is based on collaborative development with additional requirements[1], the distinctions between these aspects must be identified. Furthermore, a comprehensive review of the topic of methodologies for IS development is not possible within the framework of this research. Instead, the lessons learned from the practices of IS development are reviewed in this part of the research, with an emphasis on the approach of collaborative development.

2.5. Collaborative Development Approach

2.5.1. What Collaboration is all about

Several limitations appear that affect our ability to create almost any piece of software, since humans have narrow fields of expertise, are slow and error-prone. As a consequence, cooperation is necessary to complete large projects in a reasonable time (Whitehead, 2007). In recent years, software development has become increasingly distributed for various reasons. Indeed, the management, development and maintenance of ISs are evolving from being in a specific location to being distributed geographically. This phenomenon is variously called "global", "distributed" or "multi-site" IS development (Sengupta, et al., 2006). This is a phenomenon characterized by collaboration and cooperation between departments and organizations, creating groups of developers working together, but located in different places (Rocha, et al., 2011). A project is considered to be distributed when a development team comprises members in at least two different offices, possibly in different cities. Some authors even consider projects as being distributed when team members work in different buildings or even on different floors. In some cases, participants may be located on different continents and time zones.

Collaboration is defined as "working jointly with others or together, especially in an intellectual endeavor" (Hill, 2008). Collaboration in IS development often involves Distributed Software Development (DSD), in which case the development of a product or a service is split between geographically distributed sites. To support collaborative work

[1] The concept of community-source model, or what is called in this research "collaboratively-developed IS", differs from concepts like Distributed Software Development (DSD) or Global Software Development (GSD). For instance, in DSD the development of a product or a service is split between geographically distributed sites as a development methodology. These distributed sites do not own the system, but act as development parties that may not know what the final product is. On the other hand, the community-source model is based on a collaborative approach in which members of the consortium jointly develop the system. In community-source, it might happen that a part of the system could be outsourced using the DSD paradigm.

on projects, software engineers communicate both directly, through meetings and informal conversations, and indirectly, utilizing software artifacts[1] (Lanubile, 2009). Distributed IS development possesses many advantages. Shrivastava and Date argue that it 1) achieves greater revenue, 2) enables higher productivity and quality with lower costs and 3) creates a pool of skilled resources that are geographically distributed. They also mention that such collaboration minimizes risk resulting from natural catastrophes and other such events (Shrivastava & Date, 2010). Based on the above, the approach of collaborative development can be defined as activities involving two or more organizations, combining their competencies and technologies to create new shared value and manage their respective costs and risks. Such development may be conducted in collaboration with various stakeholders including subcontractors, third-party bodies, and in-house developers (Hyysalo, 2014).

Currently, working in geographically dispersed groups has become common practice for IS projects. This may cause additional difficulties to those of traditional IS development based in a specific location. The challenges of development tend to be emphasized and other difficulties can appear due to physical and temporal constraints (Rocha, et al., 2011) (Hyysalo, 2014) (Lanubile, 2009). Many of the challenges that arise in practice can be traced back to *inadequate communication* (particularly informal communication) between geographically dispersed team members (here, Libyan universities) who, in some cases, can be in different time-zones (e.g. ERP vendors) (Sengupta, et al., 2006). Various organizations face a wide range of difficulties due to the geographical separation of developers. Distance, time and cultural issues and differences are the main causes of these problems (Shrivastava & Date, 2010).

2.5.2. Types of Collaboration

As mentioned above, a collaborative approach to IS development is often introduced side by side with Distributed Software Development (DSD). There are four different ways to distribute software development. These four types can be first divided into two main categories according to both geographical location and the control and ownership structure of the project. *Onshore and offshore* are the dimensions based on geographical location. When all of the development work takes place in the same country as the organization's headquarters and other operations are located, it is called onshore, while offshore means that part of the development happens in a different country. Onshore distribution is also known as distributed software development (DSD) and offshore distribution is known as Global Software Development (GSD) (Shrivastava & Date, 2010). DSD is also known as domestic *outsourcing* (Yalaho, 2009). The control structure can be split into two

[1] Artifact refers to "items" that are produced in the process of software development, such as workflow diagrams, data models or other Unified Modeling Language (UML) models.

dimensions: outsourcing, where an organization buys software from some external source or *insourcing* where an organization itself provides services through some internal projects (Shrivastava & Date, 2010).

2.5.3. Collaboration in HE

In scientific and technological activities, collaboration is becoming one of the most significant features of the 21st century. However, collaborative work is not a new activity in the scientific world, but has grown gradually to become one of the most important forms of knowledge production (Grobolisek, et al., 2014). The level of collaboration among HE institutions is at present systemically increasing. Such collaboration can take many forms. Universities and colleges worldwide are encouraged to cooperate in many fields including: research, teaching, human resource development, technological innovations, academic programs, and financial resources. Malcolm also confirmed this by stating that collaboration between HE institutions has long been part of accepted practice (Malcolm, 2010). As we can see, ICT is one of the possible forms of collaboration between universities. Certainly, the collaboration between HE institutions benefits not just the HE academic community, but also the ICT community in the HE sector which shares the benefits from this spirit of collaboration, both in terms of creating leading-edge infrastructures and through a free exchange of knowledge and experience (Malcolm, 2010).

Based on the above, we cannot say whether the proposed model will be classified as outsourcing or insourcing, and whether it will be onshore or offshore. A model involving ERP would be a hybrid one following an outsourcing approach, where universities would collaboratively develop the system and configure and customize an open-source ERP system using an onshore approach. Also, such a model should not simply about traditional forms of collaboration, but rather about developing an IS collaboratively for all the beneficiaries (here the Libyan universities under the direction of the Libyan Ministry of Higher Education).

2.5.4. Critical Success Factors for Collaborative Development Approach

Most authors have emphasized three main forms of cooperation within a team: communication, coordination and control (Lanubile, 2009). These three activities are affected by several dimensions, which have been elaborated in the literature (Lings, et al., 2006). According to Lanubile, communication is the formal or informal exchange of information between members. Coordination is the act of arranging each task and organizational unit for each member to contribute to the overall objective. Control is the process of ensuring the realization of goals, policies, standards or quality levels, set either formally (e.g., formal meetings, plans, guidelines) or informally (e.g., team culture) (Lanubile, 2009) (Lings, et al., 2006). Shrivastava argues that software development requires a great deal of formal communication through vital communication channels. The

complex infrastructure required for collaborative development leads to a decrease in the frequency and quality of communication, which directly affects productivity (Shrivastava & Date, 2010). Communication is often considered to be the most critical factor in collaboration. Hence, it must be arranged properly to have successful collaborative development (Hyysalo, 2014).

Lanubile analyzed these forms of cooperation concerning three dimensions of distance: geographical, temporal/time-based, and socio-cultural. The geographical distance corresponds to team members being physically spread across different sites, as effort is needed to exchange visits between sites. Temporal distance describes the tendency of team members to work at different times of the day. This can be caused by time-zone differences (e.g. between the Libyan side and its ERP vendors) or simply shifting work patterns. Socio-cultural distance (also described by Sengupta as "the difference between organizational cultures") is the degree to which effort is required by team members to understand partners from different sites. Studies indicate that different organizational cultures may lead to less trust, poor cooperation and, ultimately, conflicts between different teams (Lanubile, 2009) (Sengupta, et al., 2006). In the proposed model, the similarities in the business processes between Libyan universities, and the geographical proximity of the sites are, in fact, key-factors.

Sengupta et al. have also added other factors such as strategic issues, about collaborative work across sites; process differences can lead to problems in synchronization and system integration; challenges to knowledge management can delay the timely sharing of knowledge (Sengupta, et al., 2006). Without an effective knowledge-sharing mechanism, development teams cannot take advantage of the benefits of collaborative development (Shrivastava & Date, 2010). Hyysalo described this as cognitive workflow since team cognition and the coordination of knowledge both support coordination and improve interactions between developers, as developers understand and anticipate what other team members will do. This includes long-term knowledge and awareness. He also argued that traditional approaches are static, and lack cognitive support (Hyysalo, 2014).

One of the major problems facing the development and maintenance of an IS is that a developer may join and leave at any point. Newly hired team members must continue the previous work. This may be difficult without what Whitehead called proper "records of organizational memory". Whitehead sees that part of the work of collaboration is recording what team members know, so that project participants can learn this knowledge now, and in the future. Likewise, records of errors and their resolution should be kept (Whitehead, 2007).

Gutwin et al. proposed the "awareness of others", which provides information that is critical for smooth and effective collaboration. Because of the complexity and interdependency of software systems, group awareness is necessary for collaborative software development. Group awareness is basically the understanding of who is working

with you, what they are doing, and how your actions interact with theirs. Some studies have shown that much of the communication and implicit information that is available to a co-located team does not exist in the case of remote collaborators. Also, Gutwin et al. argued that simplifying communication and improving the coordination of activities is one of the main benefits of group awareness in collaborative projects. Consequently, the need for awareness is subject to how much developers must coordinate. As described above by Whitehead, IS development includes dependencies and links that require knowledge of others' activities. These dependencies can cause problems when development teams are located at different sites (Gutwin, et al., 2004). Hyysalo also states that group awareness is critical to collaboration in IS development, since it enables the creation and maintenance of a shared, realistic understanding of the project that ensures individual contributions are relevant to the overall objectives (Hyysalo, 2014). Gutwin et al. also mention explicit communication[1], consequential communication[2], and feedthrough[3] as three mechanisms to help developers maintain awareness when team members are geographically dispersed (Gutwin, et al., 2004).

Other authors have emphasized technical issues, which include poor bandwidth and connectivity problems. Testing in collaborative work is problematic, since how can one carry out the effective testing of units at diverse sites where test data cannot be directly accessed in their entirety, due to data privacy and repetition issues. (Sengupta, et al., 2006). Development time; some studies indicate that tasks are undertaken via collaborative work take about two and half times as long to complete similar tasks in collocated environments; coordination costs are increased, although production costs might be lower in collaborative IS development (Shrivastava & Date, 2010).

The integration of different modules is complex, since models developed at separate locations are projected to be integrated into the whole system and errors should be minimized to smoothen the integration (Sengupta, et al., 2006). Whitehead also addressed this issue, calling it driving convergence towards a final architecture and design. Whitehead added that negotiation among system architects and designers is required to create alliances, as well as engaging experts to ensure meeting a single system architecture and design (Whitehead, 2007).

Also, Whitehead mentioned reducing dependencies between engineers. An important mechanism for managing dependencies is to reduce them where possible, thereby decreasing the need for collaboration. This means making the changes made by one developer independent of changes made by others. Based on such a work plan, developers

[1] Explicit communication occurs when developers tell each other about their activities.

[2] Consequential communication involves watching another person work, which provides information regarding their activities and plans.

[3] Feedthrough occurs when the observation of changes to project artifacts indicates who has been doing what, where artifact refers to "things" that are produced in the process of software development, such as workflow diagrams, data models or other Unified Modeling Language (UML) models

do not need to wait for other developers to finish their current changes before compiling their application (Whitehead, 2007). Dependencies can be reduced in two ways: by cutting the number of developers, or by strongly dividing the code. Some studies indicate that the greater the number of developers in a project, the greater the complexity and communication costs of a project. By having only a small set of core developers, projects can avoid such an explosion of connections and awareness can probably be easily maintained through verbal communication (Gutwin, et al., 2004).

Shrivastava and Hema Date consider project management: Managers must control the overall development process, identify interrelated tasks, minimize the dependencies between distributed teams and counteract any factors that may decrease productivity, such as unpredictable requirements, changing specifications, cultural diversity, and a lack of informal communication (Shrivastava & Date, 2010). Galviņa and Šmite argue that following one lifecycle or process model is a tool of project management. In distributed projects this is made difficult, due to organizations often having their own processes, methodologies, and tools. However, universities generally have similar environments. Lack of a clear process for executing a project leads to an increased level of frustration and decreases the feeling of ownership, which ultimately results in a very poor level of acceptance for the project plan at various locations (Galviņa & Šmite, 2011).

Prikladnicki et al. explored the need for choosing appropriate models of collaboration: Organizations intending to use such a development model need to define what methods they will use in a given project and their practices. Due to the decentralization of the development process in distributed environments, IS development becomes more complex, requiring organizations to pursue models of collaboration that meet their characteristics and needs. Hence, there must be agreement on how project leaders can arrange the model of collaboration. Prikladnicki et al. give some examples of aspects that must be taken into consideration in choosing appropriate models of collaboration, such as how a project can be split into minor activities in each phase, how each activity can be performed or how to divide the work across various sites (Rocha, et al., 2011).

Lings et al. addressed other factors including leveraging modularity**:** The architecture of a system mirrors the structure of the organization that built it (Conway's law), so a software development team plans the architecture of a system around the distributed structure of the team. This reduces the need for intensive collaboration and enables the optimal utilization of local skills. Use of cultural mediation**:** Training in cultural issues is useful. Besides, a team manager can use cultural mediators. This is a person from one team in a specific culture that spends time in another team and becomes a link person between the teams. Another suggestion is to rotate management across locations (and therefore cultures) to improve awareness. Develop an effective tool base**:** this is a common management tool for software configuration and recommended for coordination. Such a base should be available at each site. (Lings, et al., 2006).

Recognizing the importance of decision making: IS development is a complex effort that can be modeled as a set of problem-solving activities, while problem-solving, in turn, is decision making. Thus, we can understand IS development as a decision-oriented process. By recognizing the importance of decision making, we can address the above-mentioned challenges and provide synchronization and coordination to the development process. This means that developers can realize their tasks and various contributions concurrently. Hence work can be synchronized and coordinated, especially when precise decision criteria are provided and results are checked against them regularly (Hyysalo, 2014).

Hyysalo et al. addressed several other risks, including: unclear assignments, a lack of trust among partners, disagreements on intellectual property rights, and uncertainty in partners' development schedules. Further considerations arise from the continuity of collaboration, and issues regarding competences. Their study also identified factors supporting collaborative development, including fluency of co-operation, good understanding among partners of each other's work, mutual benefit from collaboration, and partners complementing each other's expertise as positive factors (Hyysalo, 2014). Table 5 presents a summary of the CSFs for collaboration in IS development. These CSFs are classified by factor type.

Table 5: A Summary of CSFs for collaboration in IS development -Source: author's own collection[1]

No.	Factor	Type
1.	Process differences (Sengupta, et al., 2006)	Managerial
2.	Challenges to knowledge management (Shrivastava & Date, 2010) (Sengupta, et al., 2006) (Hyysalo, 2014)	Managerial
3.	Coordination costs (Sengupta, et al., 2006)	Managerial
4.	Records of "organizational memory"	Managerial
5.	Group awareness (Gutwin, et al., 2004) (Hyysalo, 2014)	Managerial
6.	Appropriate communication (Shrivastava & Date, 2010) (Hyysalo, 2014)	Managerial
7.	Project management (Shrivastava & Date, 2010)	Managerial
8.	Leveraging modularity and the use of cultural mediation (Lings, et al., 2006)	Managerial
9.	Developing an effective tool base (Lings, et al., 2006)	Managerial
10.	Technical issues such as poor bandwidth, connectivity problems, etc (Sengupta, et al., 2006) (Shrivastava & Date, 2010)	Technical
11.	Recognizing the importance of decision making (Hyysalo, 2014)	Managerial
12.	The integration of different modules (Sengupta, et al., 2006)	Technical
13.	Development time (Sengupta, et al., 2006)	Technical
14.	Following a lifecycle or process model (Gutwin, et al., 2004)	Technical

[1] References are given next to each point mentioned in the table.

15.	Convergence towards a final architecture and design (Whitehead, 2007)	Technical
16.	Reducing dependencies between engineers (Gutwin, et al., 2004) (Whitehead, 2007)	Technical
17.	Recording errors and their resolution	Technical
18.	Choosing appropriate models of collaboration (Rocha, et al., 2011)	Technical

2.6. System Development Methodology

Studying system development in a distributed environment helped to explore challenges that revealed the importance of coordination mechanisms (such as system architecture, plan and process) and informal communication during development work. The system architecture has long been said to play a pivotal role in coordinating development work (Herbsleb & Grinte, 1999). According to Conway's law, organizations which design systems are constrained to produce designs which are copies of the communication structures of these organizations (Conway, 1968). Besides, in most projects, estimates of the time and resources required are inaccurate, process steps are performed incorrectly, requirements and techniques keep changing, and people leave. Thus, a specific development process is needed (Herbsleb & Grinte, 1999).

In system development, the development process or the methodology is the approach followed in implementing the SDLC phases[1] that go through from beginning to end. Planning, analysis, design, implementation and testing are the basic steps of SDLC. At the planning stage, the reason for building the system is determined and how it is going to be built. At the design phase, how the system operates is designed by the means of functional and non-functional requirements[2]. At the implementation stage, the actual system is built. Eventually, the system is tested (Dennis, et al., 2012).

There are several methodologies in system development. These methodologies have been classified as predictive or adaptive. In the predictive method, the scope of the project can be expressed accurately (also known as traditional methods) such as the Waterfall method. Meaning to say, the system is planned before starting the project. In this case, changing requirements (functional and non-functional) rarely occurs. In most approaches following the predictive model, results can be seen only at the end of the SDLC. Different processes involved in traditional predictive approaches are initiation, project planning, analysis, design, implementation, and testing. In contrast, the scope and requirements are difficult to clearly express early using an adaptive method, such as Agile methods. However, adaptive models are more flexible to accommodate change, as well as being fully adaptable in any environment. Different phases of adaptive software development

[1] A phase is set of relevant project activities to complete one or more project objectives.

[2] Functional requirements define the system functions or components such as new student enrollment, while non-functional requirements specify general characteristics such as cost and reliability requirements, also known as "quality requirements".

involve speculation, collaboration and learning (Pradeep & Wijesekera, 2017) (Dennis, et al., 2012).

Both models have their benefits and limitations. The predictive model is used in small projects, while the adaptive model can be useful for small and large projects. Also, communication is essential when using an adaptive model. It has to be face-to-face in some cases. On the contrary, the traditional model (predictive) is useful in a distributed environment where less communication is required (Pradeep & Wijesekera, 2017). As the traditional SDLC has already been discussed at the beginning of this section, Agile practice is explained in more detail, including the reasons behind involvement of the Agile method in this thesis.

2.7. Agile Software Development

Agile Software Development includes different approaches to software development, whereby requirements and solutions evolve through the collaborative effort of self-organizing. It uses adaptive planning, early delivery, continuous improvement, and rapid and flexible response to change. In practice, the Agile method can be up to ten times more productive than traditional development models when adopted by co-located teams (Phalnikar, et al., 2008). Scrum and Extreme Programming, XP, are the most common agile practices.

Agile can be described as an iterative and incremental or gradual method. Basically, the development process is accomplished through an iterative cycle of building and testing followed by assessment by the user and producer till they are satisfied with the product. This brings us to one fundamental aspect of the Agile method, since it provides the opportunity to assess the advancement of a project throughout SDLC. In this way, it resembles the Spiral method. However, in the Spiral method, a fixed number of iterations is initially determined and a plan is required for each iteration. In contrast, planning is dynamic in Agile, with an unknown number of iterations required for producing the final product (Phalnikar, et al., 2008).

The Agile method works on four principles: developing an IS that satisfies the user; changes in requirements are accepted at any stage; guaranteed cooperation between developers and customers/business, and developing on a test-driven basis prior to and after writing the code (Hneif & Hockow, 2009). In this way, the Agile method works by dividing a project into several smaller cycles, known as sprints as shown in Figure 5. Each one of them is a project in miniature which consists of design, building, testing within the pre-defined scope of work to reach the final version of the system. This mechanism ensures the fast delivery of an IS (Shrivastava & Date, 2010).

Figure 5: How Agile method works

The question raised here is why one should use an adaptive approach to SDLC, such as Agile practice, in CD-ERP which is considered an enormous project that needs future steps to be carefully planned. Indeed, CD-ERP is a distributed environment which does not suit adaptive SDLC. In fact, various issues encountered in project management within a distributed environment, such as inadequate communication and technical issues, can be avoided when using an Agile method. Indeed, Agile method has a positive effect on communication between development teams. In distributed teams, they have proved to be beneficial to the project's quality and performance. Some teams in a distributed environment follow Agile practices in a number of ways without even realizing it (Shrivastava & Date, 2010).

Also, the idea of dividing ISs into components/modules and assigning them to one of the core members is questioned in the CD-ERP model. Shrivastava and Date explained that in such a case different locations will become over-specialized in particular components. Over time, this would build up knowledge silos leaving the team with new work that can only be done by one or two people. This is due to the architecture of the system reflecting the team's geographical distribution (according to Conway's Law). This is against one of the core principles in the creation of CD-ERP. Indeed, the CD-ERP model is introduced as a promising solution to avoid issues, such as depending on a particular team when developing ISs. Also, compatibility issues occur when adopting DSD, which leads to team dysfunction by inhibiting communication; or Agile practice that relies on intense person to person communication (Shrivastava & Date, 2010). Moreover, in a changing environment, using predictive SDLC is no longer practical, although it can be used to provide an estimate of the termination date of a project. Hence, both models seem to be necessary to create great value and drive significant organizational change.

Hence, the hybrid model could alternatively be used in such a situation, which is known as Bimodal. The Bimodal term was first introduced by Gartner. Bimodal is the practice of managing two separate but coherent styles of system development: one focused on predictability; the other on exploration (Gartner, 2019). In such a case, the prediction capability reflected in a traditional approach is used side by side with an adaptive method. Before initiating a project, planning should be conducted.

2.8. Cloud Computing (CC)

In recent years, Cloud Computing (CC) has been considered to be an important topic among researchers and IT professionals in both academia and industry (Mohan, 2011). With a revenue of $127 billion in 2017 (see Figure 6) (Islam, et al., 2017), this is expected to almost double and reach $241 billion in 2020 (Duan, 2016). The concept of CC has noticeably impacted numerous aspects of the IT and business domains. Many enterprises all over the world (small, medium and even large) are progressively moving their IT systems, such as business services and applications, to clouds (Raj, 2011). CC surrounds us. Indeed, many online activities are supported in one form or another by a cloud, such as search engines (Google/Yahoo/Bing) or social networking (Facebook/Twitter) (Mohan, 2011). Generally, this shift has led to the concept of IT as a Service (ITaaS), according to which every single IT resource, activity and infrastructure is viewed and visualized as a service (Raj, 2011).

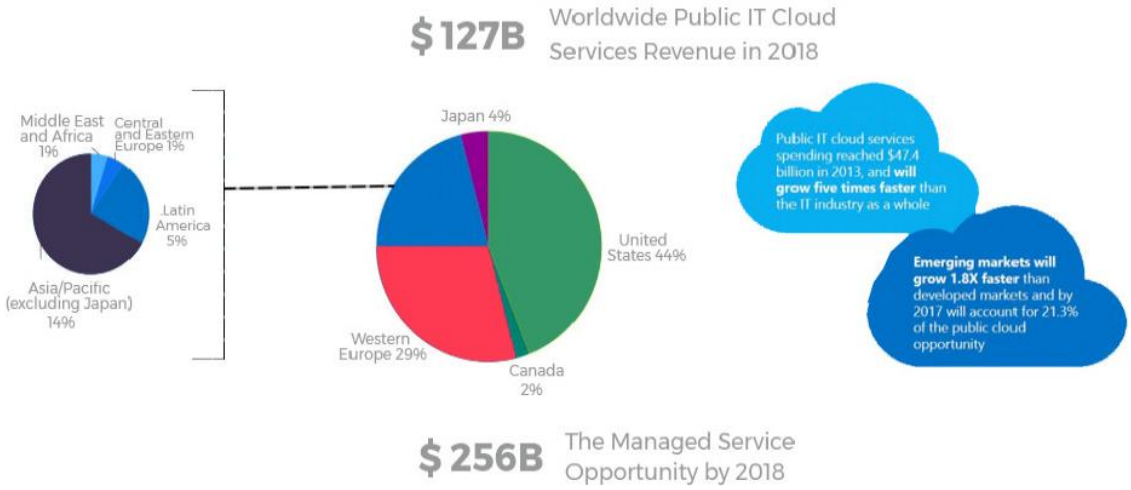


Figure 6: Regional shares in Cloud Computing - Source: (Islam, Kasem, Khan, Habib, & Ahmed, 2017)

In the Libyan context, the level of education of its citizens is increasing rapidly. Classrooms are constantly crowded. Lecturers cannot take care of students individually. This unstable situation means that students often do not attend classes. If CC is used in universities and schools, then students can benefit a lot and lecturers can pay attention to the quality of the content they upload onto the Cloud. However, despite the tangible benefits of CC, there are still problems to be solved, including privacy, security, and confidentiality (Carretero & Blas, 2014). This section provides a background to CC with an emphasis on the HE sector and its institutions.

2.8.1. Overview of the Cloud Computing Model (CC)

As cited by Mathew, the initial concept of CC dates back to 1960, when John McCarthy stated that "computation may someday be organized as a public utility"

(Mathew, 2012), while the practical application of CC was first offered by both Google and IBM in 2007 (Duan, 2016). CC may be confusing to many people, as the term can be used to mean almost anything. The main principle behind this model is offering computing, storage, and software "as a service". Although a number of efforts have been made recently to define the term "Cloud Computing", many have not been able to provide a comprehensive definition (Mohan, 2011). Voorsluys et al., however, present a definition in which they summarize almost all of the principles associated with CC. They describe CC as a parallel and distributed computerized system consisting of a pool of inter-connected and virtualized computers. CC could be offered and delivered as one or more unified computing resources based on Service Level Agreements (SLA[1]) recognized by the service provider and its clients (Voorsluys, et al., 2011). Mohan described CC as a techno-business model of using distributed large-scale data centers (private, public or hybrid) to offer a scalable virtualized infrastructure or an abstracted set of services qualified by an SLA and charged for according to the IT resources consumed (Mohan, 2011). From a technical point of view, CC combines several computing technologies including virtualization, peer-to-peer computing, grid computing, web services and service-oriented architecture (Carretero & Blas, 2014). Although there are countless definitions of CC, there are characteristics common to the most notable ones listed above (Voorsluys, et al., 2011) (Ellahi, et al., 2011) (Singh & Baheti, 2017) (Petkovics & Tumbas, 2014), namely:

- Self-service: Services can be requested, customized, paid for, and used independently.
- Services are metered and billed according to use: users are allowed to request and use only an agreed amount.
- Essentially infinite computing resources available on demand.
- Customization: This enables the specific needs of users of a multi-tenant Cloud to be individually addressed.

2.8.2. Cloud Computing in HE

As stated by Idowu and Osofisan, there is a positive feedback between ICT and education. Education feeds ICT and the latter, in return, forms the bedrock of education (Idowu & Osofisan, 2012). For higher education institutions (HEIs) to stay competitive, recognizing and adopting the latest technologies and solutions are essential. HEIs face many challenges when trying to update their IT infrastructure and data, including cost, flexibility, and accessibility, which can be solved by CC (Mathew, 2012). As an ICT

[1] An SLA is a document that informs Cloud users about the services provided by the Cloud. It tries to identify the user's needs, simplifies complex issues and creates a relationship between the user and the service provider. It helps to specify the privacy, consistency and integrity of services.

technology, CC has also brought change and prospects to the education sector. Indeed, CC is a highly valuable option for HEIs, particularly those facing funding deficiencies. Both from the technological side or the financial side, CC is a great opportunity for HEIs. Technologically, HEIs are provided with the necessary infrastructures in a CC environment to make teaching more effective, which has a positive impact on the quality of education in these institutes. Financially, HEIs can fulfill their IT needs without spending money on PCs or network hardware. Also, CC will enable HEIs to make use of global Internet resources for data analysis and data storage (Pandey, 2013). Reducing costs, and standardizing systems and resources are very difficult for HEI to accomplish with legacy technology, also called "on-premise" infrastructure. Using CC, HEIs can outsource insensitive fragments of their systems (or non-core services), to concentrate more on offering their stakeholders (students, teachers, faculties, and staff) the essential tools to help them succeed (Yadav, 2014).

To highlight the potential of CC in the HE sector, the author will refer to interesting results obtained from two studies (carried out by Gartner in 2017 and the Forrester Research Group in 2012). Gartner's survey conducted interviews with the Chief Information Officers (CIOs) of HEIs regarding several aspects. The list of "top tech areas for new spending" is of particular relevance to this research. This survey did not indicate any clear winner (see Table 6). Cyber/information security ranked first with 18%, but was followed closely by ERP with 16%. Investment in Cloud computing was also highly ranked, as were e-learning/LMS and student information systems (SIS). These results confirmed the importance of ERP and the adoption of CC, which are both essential aspects of this research (Moore, 2017).

Table 6: Priorities in spending on new technology in HE – Source: **(Moore, 2017)**

Rank	Higher Education Priorities	Respondents
1	Cyber/information security	18%
2	Enterprise resource planning	16%
3	Business intelligence (BI)[1]/analytics	15%
4	Networking, voice/data communications	14%
5	Cloud services/solutions	14%
6	E-learning/ Learning Management Systems (LMS)	13%
7	Infrastructure/data center	12%
8	Customer relationship management	7%
9	Communication/connectivity	3%
10	Student information systems	3%

[1] According to Gartner's website, the term BI refers to the applications, infrastructure and tools, and best practices enabling the access to and analysis of information in order to improve and optimize both decisions and performance.

In the Forrester research report, 12 universities in the US, the UK, Australia, New Zealand, and India were surveyed. CIOs and IT directors in these universities were interviewed concerning the degree of adoption of Cloud technologies. The key observations of this study are as follows: the most valued features of CC in HE are its functionality, scalability, and agility; IT directors prefer private clouds; universities have a strong interest in community clouds; HEIs want long-term contracts with vendors, but do not trust Cloud security (Forrester Research Group, 2012).

2.8.3. Critical Success Factors (CSFs) for CC adoption in HE

Generally, the literature has highlighted a substantial number of challenges concerning CC in any field. Such challenges and risks must be taken into consideration, to implement CC to its best effect. Voorsluys et al. mention several issues related to CC that range from security to regulation, such as 1) security, privacy, and trust: this challenge was argued to be the main issue since CC must be made as secure as in-house IT systems; 2) legal and regulatory issues: using CC, data may be located anywhere in the world, thus it might be difficult to execute national regulations. Sensitive data, such as staff records, should be stored within national borders, which could be a possible solution to such an issue; 3) data lock-in and standardization; this is a major concern in CC, since moving data and applications are not easy, an example of this is when a cloud provider no longer meets the requirements of users; a possible solution is standardization. One well-known standard is the Unified Cloud Interface (UCI), which was formed by organizations from The Cloud Computing Interoperability Forum (CCIF), such as Intel, Sun, and Cisco; 4) availability, robustness and the ability to recover: users doubt the abilities of cloud services in these fields; and 5) resource management and energy-efficiency (Voorsluys, et al., 2011). Besides matters of security, Mohan added: performance monitoring; consistent and robust service; meta-scheduling; energy-efficient load balancing; scale management; Service Level Agreements (SLAs) and Quality of Service (QoS) architectures; and interoperability and portability (Mohan, 2011). Raj discusses issues related to CC, such as controllability; visibility and flexibility; security and privacy; high performance and availability; integration, composition, and standards. Raj also emphasized the difficulties of software integration, stating that CC has brought new challenges to the complex integration channel matrix, since local applications have to be connected to the Cloud, and Cloud applications have to be connected to each other. Also, Raj states that one of the most promising solutions to avoiding the inefficiencies and deficiencies of CC are deployment models themselves, such as private Clouds, hybrid Clouds and, in particular, community Clouds, which are rapidly gaining popularity (Raj, 2011).

These challenges and risks are considered to be obstacles to the adoption of CC in the HE sector. Hence, it is important for HEIs to take into consideration these challenges and risks before switching to CC based systems, in order to avoid failures. Also, technical and cost considerations are not sufficient on their own to justify adoption. Indeed, Pandey

indicated that the importance of information flow could have far-reaching political, social and economic effects on students, faculty, and society (Pandey, 2013). Mathew mentioned that for HEIs to adopt CC, they have to first define their requirements and to pay special attention to privacy and other critical issues associated with CC (Mathew, 2012).

Another important issue is the sensitivity of data in the HE sector, since CC data centers are based in many countries. This issue was mentioned above, concerning the national regulation of an organization. Certain countries have very strict rules about cross-border transfers of personal information, and complying with such rules can be challenging in the virtual world of the Cloud. Universities, of course, are typically subject to laws and regulations dealing with data on academic grades, especially in Libya, where public universities are completely funded by the government. Other laws and regulations concerning privacy, data integrity and maintenance, intellectual property management, and audit trails should also be observed (Pandey, 2013).

Vulnerability to security breaches was also mentioned by Pandey as an issue of CC that concerns HEIs. Security matters include: the loss of governance, lock-in issues, isolation failure[1], risks of a lack of compliance to legal regulations [2], compromising of the management interface, data protection, incomplete or insecure data deletion and malicious insiders (Pandey, 2013). Yadav notes that HEIs may prefer to store their own data in-house for more secure access (Yadav, 2014). This is confirmed by Mathew, who states that privacy is one of the important factors of CC. HEIs should be very careful about disclosing their data and not lose the integrity of these data. To ensure the security and protection of sensitive data in the Cloud, Mathew lists some points, including masking or de-identifying the data; firewalls; encryption and decryption; and control over authorization (Mathew, 2012). Another security issue lies in the fact that Cloud providers sometimes target users with unwanted e-mails or advertisements (Yadav, 2014) (Kiryakova, 2017).

Kiryakova also considers security issues in which data protection is also mentioned. Concerning security matters, the following are possible solutions to the problem of data security: 1) deployment in a private Cloud, which is more secure than a public Cloud, 2) data separation and deployment in several Clouds, supported by different vendors, which may provide a higher level of security and avoid vendor and data lock-in (the main drawback of this solution is that the transfer of data between Clouds is not always possible and can put data at risk), 3) not to deploy critical data and applications in a Cloud, but continue to store them on local servers which are under the control of the organization.

[1] This risk involves the failure of the isolation mechanism that separates different tenants in the Cloud.

[2] As Cloud service providers may host data in multiple locations, this creates new challenges for senior information officers, such as compliance to the law and regulations of the country where the organization (tenant) is located. Consequently, compliance with these laws falls directly on the organization, not the Cloud providers.

The following are common solutions to the problem of data protection: 1) data encryption before deployment in the Cloud; 2) direct collaboration with a service provider, without the use of intermediaries, since the presence of multiple intermediaries increases the risks to data security and protection (Kiryakova, 2017). Kumar et al. also criticized the lack of data privacy in CC due to other factors: multi-tenancy, reuse of hardware and software, which could mean greater risks to confidential data in the possession of HEIs (Kumar, et al., 2013).

Mathew mentions other challenges, including: not all applications can run on Clouds; lack of organizational support; the speed or lack of an Internet connection can affect work; maturity of solutions; and adherence to standards (Mathew, 2012). Kumar et al. note a very critical risk of failure, which they call "Cloud Service Failure", i.e. that some Cloud providers might go out of business, resulting in a loss of investment at any time, which in turn makes universities face the risk of having to perform their duties and obligations. Kiryakova also considers the issue of transferring content from one system to another, which is associated with expenses and is not always possible, even though most CC providers claim that they ensure and facilitate migration to other vendors (due to the compatibility of products and services) (Kumar, et al., 2013). Kiryakova sees the commitment to and dependence on a specific provider and the inability to switch to others as the main risk of CC. Kiryakova argues that a possible solution to this problem is the institution of open standards and adherence to them by vendors (Kiryakova, 2017). Pandey criticizes Cloud vendors whose SLAs are not specific or detailed enough to meet the requirements of HEIs (Pandey, 2013).

Besides security concerns, Islam et al. mention other risks and challenges, including: interoperability when no universal standards have been defined; users' ability to control quality in CC varies greatly; reliability; and platform or language specificity, i.e. only particular languages or platforms are supported by certain CC providers (Islam, et al., 2017). Kiryakova also agrees with Islam, stating that data control is in the hands of the CC providers, rather than the HEIs (Kiryakova, 2017). Moreover, based on the Forrester Research Report, a lack of customization indicates a challenge to HEIs, since additional data-driven functionalities are tied to the identity of the user. Also, licensing arrangements may cause concern, including: changes in SaaS licenses according to the level of use; and licensing agreements that could block in-house applications being deployed in the Cloud (Forrester Research Group, 2012). Table **7** presents a summary of the CSFs for CC adoption in the HE sector. These CSFs are classified by factor type.

Table 7: Summary of CSFs for CC adoption in the HE sector - Source: author's own collection[1]

No.	Factor	Type
1.	Legal and regulatory issues. (Voorsluys, et al., 2011) (Pandey, 2013)	Managerial

[1] References are given next to each point in the table.

2.	Data lock-in and standardization. (Voorsluys, et al., 2011) (Raj, 2011) (Mathew, 2012) (Islam, et al., 2017)	Managerial
3.	Performance monitoring (Mohan, 2011)	Managerial
4.	Controllability, i.e. control of the data is in the hands of the CC providers, rather than the HEIs (Raj, 2011) (Kiryakova, 2017) (Islam, et al., 2017)	Managerial
5.	Complex integration (Raj, 2011)	Managerial
6.	Organizational support (Mathew, 2012)	Managerial
7.	An SLA may not be specific or detailed enough to meet an HEI's requirements (Pandey, 2013)	Managerial
8.	Security, privacy, and trust. (Voorsluys, et al., 2011) (Mohan, 2011) (Pandey, 2013) (Yadav, 2014) (Kiryakova, 2017) (Kumar, et al., 2013)	Technical
9.	Availability, robustness, and ability to recover from a disaster. (Voorsluys, et al., 2011)	Technical
10.	Resource management and energy-efficiency. (Voorsluys, et al., 2011)	Technical
11.	Not all applications can run on Clouds (Mathew, 2012)	Technical
12.	Low speed or lack of an Internet connection (Mathew, 2012)	Technical
13.	Failure of a Cloud service or lack of compatibility of products and services. In other words, dependence on a specific provider (Kumar, et al., 2013) (Kiryakova, 2017)	Technical
14.	Only particular languages or platforms are supported by some CC providers. (Islam, et al., 2017)	Technical

2.9. Multi-Tenancy

Technically, multi-tenancy is an approach to software architecture in which a single instance of a software application serves multiple customers, referred to as tenants. One application is run on a single database for multiple organizations. Academically, multi-tenancy has not yet received a large deal of attention in research (Bezemer & Zaidman, 2010). Furthermore, multi-tenancy is a term that is always associated with Cloud Computing (CC). Indeed, multi-tenancy is a major characteristic of CC. Compared to single-tenancy, multi-tenancy is the most direct path to spending less on and getting more from CC. Furthermore, multi-tenancy is a key common attribute of public and private clouds which applies to all three layers of CC: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS) (Jani, et al., 2013). At the same time, multi-tenancy is considered to be one of the most serious issues in Cloud security. In this part of the research, a brief introduction to multi-tenancy and its types, the benefits and challenges associated with it and finally its relevance to this research are all presented (Bezemer & Zaidman, 2010).

2.9.1. Overview of Multi-Tenancy

The term multi-tenancy is related to many resources including: software architecture, databases, and infrastructure. Basically, multi-tenancy is an architecture enabling a single instance of software to be accessed by multiple tenants via the service provider's infrastructure. A multi-tenant application allows tenants to share the same hardware

resources in which a shared application and database are offered. As such an application runs on a dedicated environment, tenants are allowed to configure it to their needs (Bezemer & Zaidman, 2010). Kabbedijk et al. highlight this by defining multi-tenancy as a system where multiple, possibly varying, clients and their end-users share the system's services, applications, databases, or hardware resources, to lower costs (Kabbedijk, et al., 2014). The instances (tenants) are logically isolated, but physically integrated (Gartner, 2019).

For example, consider CC offered to multiple users where each user is considered to be a tenant. Such users need similar resources that are allocated in a single instance of CC. The costs are then shared between these users, while they can easily access, maintain, configure and manipulate the data stored in a single database running on one platform (Mukundha, et al., 2017). A tenant is an organizational entity, typically a single body or a group of customers that rent multi-tenant software (Bezemer & Zaidman, 2010). These definitions are described in general terms where multi-tenancy refers to resource sharing in CC and multi-tenancy could be viewed differently under other service models in CC (AlJahdali, et al., 2014).

Also, some authors differentiate between single-tenancy and multi-tenancy architectures to clear any confusion. In a single-tenant architecture, each tenant has a separate physical instance of an application, while many tenants could share a single physical instance in a multi-tenant architecture (Betts, et al., 2012). Applications may differ under a single-tenant architecture where each tenant has its own version, while in multi-tenancy architecture this is not possible, since the application only comes as one version and can only be configured at runtime based on a particular tenant's needs (Bezemer & Zaidman, 2010). Although applications in a single-tenant architecture are often customized, customization requires changes to an applications' code. Moreover, upgrades are time-consuming under single-tenancy, since an update may not be compatible with customization. On the other hand, most multi-tenant applications are designed with the ability to be highly configurable without changing the source code or data structure, so that upgrades can be performed easily. In terms of security, the maximum privacy and enhanced security are obtainable under single-tenancy, since it delivers true data isolation. On the other hand, when one tenant's system goes down under a multi-tenant architecture, the rest of the tenants' systems go down as well, while under a single-tenancy architecture, failure can be isolated (Jani, et al., 2013). Under multi-tenancy, multiple tenants share application and data instances, which makes the total number of times that instances are run lower than in a single-tenant environment catering to the same number of tenants (Kabbedijk, et al., 2014).

2.9.2. Types of Multi-Tenancy

Multi-tenancy comes in three kinds or degrees which are distinguished according to the level at which the core applications, SaaS, or the layers (e.g.: application layer,

database) are designed to be shared across tenants' architecture. These three types of multi-tenancy are described in the list below. The first type allows consolidating only a few tenants onto one machine, due to the large main memory footprint of a database instance. Under the second type, each tenant obtains a dedicated schema instance defining e.g. access to data. The third type seems to be suitable for a large number of small tenants, because it offers the lowest overheads per tenant (Jani, et al., 2013) (Kabbedijk, et al., 2014) (Bezemer & Zaidman, 2010)) (Schiller, et al., 2011) (Pallavi & Jayarekha, 2014).

- Shared application, a separate database: each tenant obtains a private database instance while sharing a single machine.
- Shared application, shared database, separate database tables: which is also known as a "Shared Process", where each tenant obtains a private set of tables while sharing a single database instance.
- Shared application, shared database table: which is also known as "Pure Multi-Tenancy", where each tenant shares a single database instance and a single set of tables.

2.9.3. Benefits of Multi-Tenancy

The benefits of multi-tenancy have been identified and described in the literature. Generally, the benefits of multi-tenancy lay in two points. Since there is only one application instance, the maintenance of applications becomes easier and cheaper (Bezemer & Zaidman, 2010). Also, the utilization of hardware is improved (Bezemer & Zaidman, 2010) (Kabbedijk, et al., 2014). Consequently, these two benefits reduce the overall costs of running applications, as well as giving the ability to share infrastructure and the operational costs of the data center (Jani, et al., 2013). Other benefits of multi-tenancy include the following: updates only have to be inputted for a small number of instances; new opportunities for data aggregation are opened because all of the tenants' data are in the same place (Bezemer & Zaidman, 2010); clients are not responsible for purchasing and maintaining expensive in-house servers (Kabbedijk, et al., 2014); access to the latest releases is seamless and faster (Mukundha, et al., 2017); the configuration of applications is much easier and does not affect other tenants' instances of applications (Mukundha, et al., 2017); it is easier to back-up an application and its data; lower system requirements, since it is not necessary to have a server dedicated to each tenant, while applications and databases are shared (Pallavi & Jayarekha, 2014).

2.9.4. Drawbacks of Multi-tenancy

Multi-tenancy faces various challenges, although challenges exist for single-tenancy as well. Software developers see multi-tenancy as an opportunity, while security experts see it as a vulnerability. Indeed, multi-tenancy has been identified as a security issue in CC by several researchers. These challenges appear in different forms and are sometimes more difficult to solve than in the case of single-tenancy. Many authors working in this

area have talked about three major challenges, namely: scalability, security, and the performance of applications run as multi-tenant.

Scalability is an issue for service providers, since all the tenants share the same application and data-store. Moreover, tenants could come from various geographical locations, which can have an impact on the requirement for scalability (Bezemer & Zaidman, 2010) (Pallavi & Jayarekha, 2014). Indeed, when tenants come from various geographical locations, there may be different laws and regulations put in place by different governments. Knowledge of these different laws and regulations is also to be considered (Matthew, et al., 2014).

Even though sharing hardware can be an advantageous feature, it seems to be a challenge as well, especially when multiple tenants share the same resources and hardware utilization is higher on average. To solve such a problem, assigning an equal amount of resources to each instance might be considered, but this may lead to inefficient utilization of resources and is therefore undesirable in a multi-tenancy architecture (Bezemer & Zaidman, 2010) (Pallavi & Jayarekha, 2014).

Other scholars have mentioned the challenge of re-engineering current software applications to multi-tenancy architecture, as well as selecting the appropriate multi-tenant architecture. These are complex problems since there are numerous alternative architectural patterns (Kabbedijk, et al., 2014). Several factors influence the decision to select a multi-tenancy architecture, such as the size of the tenants' databases; the number of tenants; the number of users per tenant; the growth rate of tenants; the growth rate of tenants' databases; security and cost. Another major issue is system flexibility. A multi-tenant application must be able to serve hundreds, or even thousands, of tenants through one instance (Matthew, et al., 2014).

Furthermore, customization should not impact other tenants during runtime under multi-tenancy. Also, any tenant's developer should be able to easily deploy their existing applications onto multi-tenant architecture without any large code changes. Monitoring service delivery and availability is another issue, especially when failures occur or certain services generate abnormalities that could interrupt service delivery (Mukundha, et al., 2017). Table 8 provides a summary of the above issues (drawbacks and benefits).

Table 8: Considerations to be taken into account in developing a multi-tenancy architecture - Source: author's collection

No.	Factor
1.	Strictly isolated tenancy is needed to help ensure the highest level of information security and scalability. Isolation should be carefully considered in almost all parts of the architecture design from various aspects, both functional and non-functional, e.g. security, performance, availability. (Mukundha, et al., 2017) (Matthew, et al., 2014)
2.	Reliable assignment of an equal amount of resources to each instance. (Bezemer & Zaidman, 2010) (Pallavi & Jayarekha, 2014)
3.	The service level agreement (SLA) has to provide very strong guarantees of data security. (Matthew, et al., 2014)

4.	Knowledge of relevant laws and regulations when responsibilities should be divided to meet regulatory requirements. (Matthew, et al., 2014)
5.	Re-engineering of current software applications to the multi-tenancy architecture adopted. (Kabbedijk, et al., 2014)
6.	Selecting the appropriate multi-tenant architecture. (Kabbedijk, et al., 2014)
7.	A multi-tenant application must be able to serve hundreds, or even thousands, of tenants through one instance. (Matthew, et al., 2014)
8.	Customization should not impact other tenants during runtime. (Mukundha, et al., 2017)
9.	Any tenant's developer should be easily able to deploy their existing applications on the multi-tenant architecture without any large code changes. (Mukundha, et al., 2017)
10.	Reliable monitoring service delivery and availability, since one error could interrupt the whole service delivery. (Mukundha, et al., 2017)

2.10. Summary

A comprehensive review of all these topics is not possible within the framework of this research. Instead, the basic elements of the CD-ERP model have been covered, as well as the models and techniques used. As an important element of the CD-ERP model, ERP was covered in detail, including its general benefits and drawbacks, ERP issues specifically related to HE, reasons for unsuccessful implementations of ERP and a list of CSFs for ERP implementation. The author notes that most of these CSFs are related to managerial aspects rather than technical ones. At the same time, the CD-ERP model is based on the community-source principle in which systems should be developed jointly. As a result, the collaborative-development approach was also covered. The observations indicate that the development of software is no longer limited to an individual developer, but is distributed over a networked world of information and computer-mediated collaboration. Also, communication, coordination, and control are three aspects that must be taken into consideration in distributed development, such as community-source. Cloud technology and multi-tenancy architecture could be used in combination with collaborative-development to achieve greater benefits, such as reducing the cost of investment in infrastructure and human resources for the universities participating in the consortium. The following chapter presents the methodology used in this study, as well as a justification of the methods used for data collection.

CHAPTER THREE: THE METHODOLOGY

3.1. Introduction

Research, on the whole, is aimed at establishing new awareness, understanding, comprehension, or knowledge regarding a specific topic, problem, or issue. Towards this goal, research experts have introduced different research methodologies to provide researchers with the techniques they need to meet the diverse nature of research. Indeed, research methodology plays an important role in any academic study. Essentially, any research methodology is defined by the specific procedures or techniques used to identify, select, process and analyze relevant information. Although ISs are considered to be a new field, various research methodologies have been introduced in this area. In the field of ISs, the methodology of research can be classified according to a variety of dimensions, such as technology, management, political science and strategy (Wedawatta, et al., 2011). In this chapter, the research elements used in this study are summarized including: the strategy and approach followed, the research method used, the method of data collection, the sample, the research process, data analysis, models and techniques used and the delimitations of the research.

3.2. Research Methodology

The description of the research methodology will be based on the concept of the Research Onion. There are several definitions of the methodology proposed by different authors. The methodology of research proposes a logical approach to introducing innovations in teaching and learning. It sets lecturers in the twin roles of being both a creator and user of the theory of education. This is a technique for creating knowledge about higher education learning and teaching, and an influential technique for improving learning and teaching practice (Boland & Collopy, 2004).

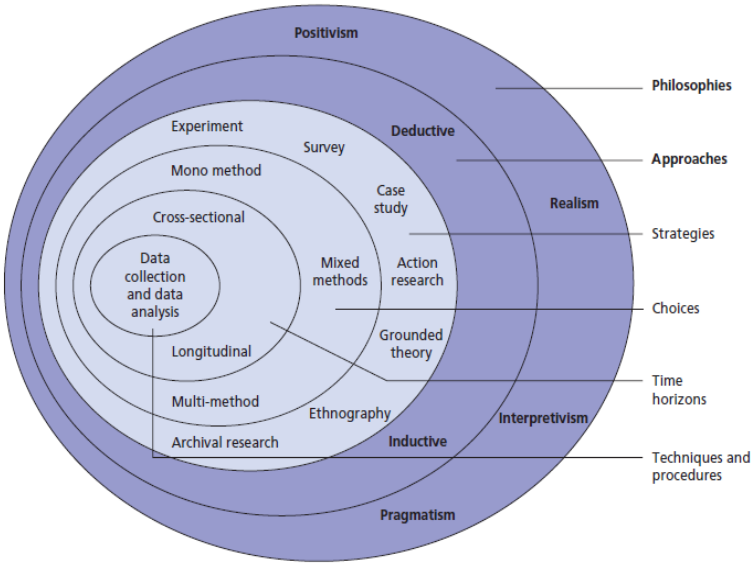


Figure 7: The research 'onion' - Source: **(Saunders, et al., 2015)**

Methodology, as defined by (Dawson, 2002), is the philosophy or the general principle that guides researchers in their studies. It is the overall approach to studying a topic and includes issues that need to be thought about, such as the constraints, dilemmas and ethical choices existing within a research project. It was defined as a procedure that people undertake to study things systematically, thereby increasing their knowledge (Saunders, et al., 2015). It was described as a systematic approach to gathering data, which is often aimed at comparing people, documents or even test records using such activities as description, explanation, and understanding (Brown & Rodgers, 2002).

3.2.1. Research Philosophy

Any research is meant to develop and create new knowledge based on data collection and analysis along with careful observation. The knowledge developed is usually new knowledge in a particular field based on existing knowledge and what has been investigated (Pearlson & Saunders, 2010). Saunders and his team use the term "research philosophy" to reflect how a researcher reasons about the development of knowledge and how this influences how the researcher decides to conduct research. According to Galliers, a research philosophy is a belief about how data about a phenomenon should be gathered, analyzed and used. There are several research philosophies namely: positivism, realism, interpretivism, and pragmatism. The debate on research philosophy is often framed in terms of a choice between either a positivist or interpretive research philosophy (Saunders, et al., 2015).

The field of ISs, by its nature, intrinsically lies within the realm of both the social sciences and the technical sciences. Thus the scientific paradigm adopted by the natural sciences is appropriate to studying ISs, while Holl and Fachhochschule described ISs as a

profitable area for applying epistemology – the theory of knowledge (Fachhochschule, 2019). Fallis argued that, of all the branches of philosophy, epistemology is the most relevant to information studies (Fallis, 2006). Holl and Fachhochschule argued that the aim of ISs as a field is to develop business IT systems in enterprises. Such IT systems are formal machines (akin to models) which cannot comprise the reality of a company in its entire complexity, but only in a reduced form. They added this because the fundamental problems of modeling are of epistemological nature, IS applications often do not meet users' needs and they often exceed their budgets to a great extent. Hence, epistemology is needed in the field of ISs (Fachhochschule, 2019).

Epistemology is the study of how one becomes aware of certain aspects of reality, especially concerning the methods, validity, and scope of gaining knowledge, and the distinction between justified belief and opinion (Hirschheim, 2000) (Myers, 2013) (Given, 2008). Unlike ontology (the study of being), epistemology concentrates on what is known to be true. Today, positivism and interpretivism are the two main epistemological approaches used in research practice in the field of ISs (Fallis, 2006).

The positivist approach is usually connected with quantitative research in which phenomena must be measured to develop an understanding that is supported by evidence. Using this approach, the methods of the natural sciences are applied to the study of the social sciences (Crotty, 1998) (Hammersley, 2013). This approach offers researchers an understanding of objects utilizing empirical approaches, such as questionnaires, sampling, focus groups, and measurement. As a result, a high standard of validity and reliability is provided (Cohen, et al., 2007). This approach is quite common in social research, since it can be generalized or replicated to different groups or subgroups of a population in social contexts. However, such generalization is often considered to be a drawback, especially when large degree generalizations of research results are made (Myers, 2013) (Given, 2008).

The interpretive approach emphasizes qualitative analysis rather than quantitative. It involves a human interest in a study where a single phenomenon may have multiple interpretations rather than being subject to a truth that can be determined by a process of measurement. Also, it may require researchers to interpret the elements of a study using multiple methods, to reflect different aspects of the issue being studied. In the social sciences, the development of interpretation is based on a critique of positivism. Instead of aiming to gain an understanding of the population as a whole, individual objects, humans or events are studied to gain a deep understanding of them in their particular social context (Creswell, 2007). The latter is considered as a drawback by (Cohen, et al., 2007).

In this study, epistemology (the theory of knowledge) is used together with an emphasis on the positivist and interpretive approaches. The author has used qualitative methods within a positivist paradigm by conducting comparative case studies of Libyan universities under the assumption that these cases might differ. Practically, the collaborative approach primarily includes all forms of HEIs (such as universities,

community colleges, research centers) within LHE that wish to join the consortium. It is impractical to include all types of HE. The author used Libyan universities as a model in studying the applicability of such an approach in HE institutes in Libya. Such an approach seems justified, since a university carries out the full range of activities that are observed in HE institutes (whereas other institutes may be more teaching based or research based). Also, universities are probably considered the best HE institutions to study developing ISs through the cooperative approach in terms of resources, whether human or other. Indeed, universities have much more human expertise and financial capabilities than colleges and research centers. For example, research centers can provide assistance in the case of developing a research information system (RIS). Colleges can also provide technicians who are able to assist in software development. However, it should be borne in mind that such assistance is somehow insubstantial due to the limited resources available, whether for research centers or colleges because such institutes are relatively small as I mentioned earlier. Hence, case studies based on universities will give us a full picture of the ISs that are needed in HE and reflect the human resources that are available.

Based on the above, qualitative data is collected from these cases to assess this assumption. A series of interviews with participants from the subjects of the case studies were conducted. The output of these interviews comprises narrative observations, which are based on the participants' knowledge and experiences related to the topic of this study. The author analyzed these observations by interpreting the contextual features of the participants' experiences taking into consideration the observations from the literature review and international experiences.

3.2.2. Research Strategy

According to Saunders, a research strategy is a general plan that helps researchers to answer research questions systematically. To conduct a research study efficiently, researchers need an effective research strategy. Moreover, having a research strategy is important in helping a researcher to answer the research questions and meet the study's aim and objectives (Saunders, et al., 2015). As illustrated in Figure 9 (the Research Onion of Saunders et al.), some of the research strategies in a scientific area may include experiment, survey, case study, grounded theory, ethnography, action research, and archival research. One of the strengths of this variety of possible approaches is that it allows researchers to use a range of sources and different sorts of data as part of the exploration process (Denscombe, 2007), and this is suitable if a researcher needs to gain a rich understanding of the context of the research and the processes involved (Saunders, et al., 2015) (Velde, et al., 2003).

The main distinction to make when implementing a case study design is between a single case and a multiple-case design (Yin, 2013). Also, the question arises here as to whether a single case or multiple ones should be considered. One major advantage of using a single case study lies in the ability to focus on a single case, since an intensive

examination of a single case is possible even when research resources are relatively limited (Yin, 2013). On the other hand, the use of multiple cases helps to ensure that conclusions are based on comparable outcomes and common patterns rather than a generalization made from what could be one-off chance occurrences (Fowler, 1993). Since one of the goals of this approach is to suggest an approach to developing the ISs used in university education within Libya as a whole, the information should be gained from several universities. Consequently, in this study, the author has chosen multiple case studies where the subjects are[1]: University of Tripoli (UOT) – Libya; Misurata University (MU) – Libya; and University of Sirte (SU) - Libya.

3.2.3. Research Approach

Two research approaches that involve the relationship between theory and data are the deductive and inductive approaches. A research strategy is deductive when conclusions are drawn based on given facts. The focus of a deductive approach to research is to explain the causal relationships between variables, which requires collecting quantitative data together with the use of statistical tools for testing relationships (Bryman & Bell, 2007). The inductive approach is associated with qualitative research: the researcher collects data and develops a theory as a result of data analysis (Saunders, et al., 2015). Under an inductive approach, data are collected before being analyzed to develop a theory. Inductive research is usually undertaken to gain an understanding of the meanings, attitudes or perceptions that human beings attach to or develop towards events and stimuli (Sproull, 1988). The main difference between these approaches to research is that whilst a deductive approach is aimed at testing a theory, an inductive approach is concerned with the generation of a new theory that emerges from the data.

Moreover, (Collis & Hussey, 2013) and (Saunders, et al., 2015) encouraged combining the deductive and inductive approaches within the same piece of research (see also Majda, 2015). In this research, both the deductive and inductive approaches were used. The author investigated the conditions for implementing CD-ERP using a study of the literature and then considered international experiences of such systems (deductive). On the other hand, the observations from the fieldwork in Libya - multiple case studies - were integrated into the existing philosophy (inductive).

3.2.4. Data Collection

The three characteristics of the qualitative method in research are inductiveness, constructiveness, and interpretation. The method of qualitative research involves the

[1] At the beginning of this research, three universities were chosen as cases studies based on their size and founding year. Later after conducting the initial study in which UOT works as one case, it was possible to decide whether or not to include more case studies of Libyan universities.

analysis of the data gathered (categorical and/or descriptive) and presents an avenue for a descriptive interpretation of a study (Bryman, 2001). Quantitative research is deductive in nature, where the theory applied depends on a literature review. From such a review, one formulates a general hypothesis and moves to specific details (Hussey & Hussey, 1997). According to (Fowler, 1993), quantitative research involves the analysis of statistical data and the observations are presented in numerical form.

The mixed-mode of research, also known as the combination method, is a combination of the quantitative and qualitative methods. (Bryman, 2001) and (Fowler, 1993) both observed that these two research methods do not usually exist in isolation during research. Using a mixed approach can appropriately develop the strengths of these two methods and neutralize or cancel out some of their weaknesses. The author intended to use a mixed approach, applying a quantitative method to analyze the international experiences, while applying the qualitative method to analyze the Libyan context. Unfortunately, none of the representatives of the international experiences that follow community-source approaches replied to the researcher. Instead, cases from these projects were included on the basis of a documentation review, as well as the material published online.

3.2.5. Methods of Data Collection

The methodology of a study is a different concept from that of methods used to gather data, which is termed "data collection and data analysis" in the Research Onion described by Saunders and others (see Figure 9). These methods could range from interviews, the administration of questionnaires, group focus, discourse analysis, and participants' observations. In fact, no method suits all studies. The appropriate methods of data collection are normally determined by specific necessities; the research philosophy, the research approach, the research strategy, and the aim of the research (Yin, 2013). In this research, the strategy of data collection via case studies has been chosen. (Yin, 2013) listed five sources of information gathered by data collection in a case study: interviews, observation, documentation (study of documents), archival records and physical artifacts. Generally, the main methods of data collection that have been chosen for this study are: interviews, questionnaires and study of relevant documentation. These methods were selected on the basis of particular characteristics of this research, the research philosophy, the research approach and the research strategy chosen. The different positions of the participants involved and a mixed-method approach should help in cross-relating the findings of this study. The data were collected in three stages:

First - A literature review: conducting a review of the literature relevant to this study.

Second – A survey of international experiences. Data collected via a questionnaire were intended to support the main part of the study, to enhance the validity of the research by investigating the CD-ERP model adopted. However, due to the lack of collaboration from

the relevant international organizations, cases from other projects that follow a similar approach are included as an alternative.

Third – Face-to-face and semi-structured interviews in case studies and a review of documentation. This will be the main source of evidence used to test the hypotheses.

1) Interviews

An interview is the most common method used in qualitative research (Bryman & Bell, 2007). Interviews are a valuable method of collecting suitable and reliable data related to the research questions or objectives. In social research, there are many types of interviews. The most common of these are unstructured, semi-structured and structured interviews (Dawson, 2002).

a) Unstructured Interviews

Using this type of interview, a researcher attempts to achieve a holistic understanding of interviewees' points of view or situations (Dawson, 2002). Using such an approach, the interviewer needs to have a clear idea about the aspects requiring exploration, since there are no pre-determined questions to work through (Saunders, et al., 2015). Also, it is important to realize that unstructured interviews can produce a great deal of data that can be difficult to analyze (Dawson, 2002). Since no pre-determined questions are used by the interviewer in this type of interview, the comparability of the questions asked and responses obtained may be a problem (Kumar, 2018).

b) Structured Interviews

In structured interviews, researchers should prepare a set of specified questions in what is called an "interview schedule", so that the same wording and order of questions are used in each interview (Kumar, 2018). This research method is highly structured – hence the name. Structured interviews are used in quantitative research and can be conducted face-to-face or over the telephone, sometimes with the aid of lap-top computers (Dawson, 2002).

c) Semi-structured Interviews

Semi-structured interviews are perhaps the most common type of interview used in qualitative social research (Dawson, 2002). As the name suggests, a mixed-mode of interviews is conducted when using this method. A semi-structured interview encompasses many of the advantages of both methods (Flick, 1998), such as flexibility in providing rich information, due to the freedom enjoyed by the interviewer that is normally associated with unstructured interviews. On the other hand, semi-structured interviews can also avoid many of the disadvantages typically related to unstructured interviews. For example, as a researcher gains experience during a set of interviews, the questions asked of respondents may change. In this case, "the type of information obtained from those who are interviewed at the beginning of a study may be markedly different from that obtained

from those interviewed towards the end" (Kumar, 2018). However, semi-structured interviews are time-consuming, which is of particular significance if there are a great number of respondents to be interviewed; Besides, the problem of accessibility may arise (Hussey & Hussey, 1997).

2) Questionnaires

According to (Bryman, 2001), a questionnaire consists of several questions related to the subject of the research, where the answers are expected to enable the achievement of the aims and objectives of the research. According to the definition of a questionnaire, the person answering the questions records their own answers, although it is sometimes used as a more general term to also include structured interviews that are administered either face to face or by telephone. For example, Saunders et al. used questionnaire as a general term to include all the techniques of data collection in which each person is asked to respond to the same set of questions in a predetermined order. Also, questionnaires may be closed-ended questionnaires (where answers are either numerical or chosen from a given set of categories), open-ended questionnaires or a combination of both (Saunders, et al., 2015).

Closed-ended questionnaires are probably the type with which users are most familiar. This type of questionnaire is used to generate statistics in quantitative research, as questions follow a set format. Open-ended questionnaires are used in qualitative research, although some researchers quantify (classify) the answers during the analysis stage. Nevertheless, many researchers tend to use a combination of both open and closed questions. In such mixed questionnaires, they begin with a series of closed questions, with boxes to tick or scales to rank, and then finish with a section of open questions for more detailed responses (Dawson, 2002).

In the case of international experiences, the data collection technique was intended to be based on questionnaires (closed-end questionnaires) distributed to selected international organizations online. The purpose of these questionnaires was to collect data on the implementation of CD-ERP according to international experience, the information system adopted, factors (both positive and negative) affecting the implementation of CD-ERP in these cases, and other related information. Unfortunately, no representative of any of these organizations replied to the researcher. Instead, cases of other projects that follow a similar approach are included on the basis of literature and documentation reviews. In the case of LHE, the research is based on case studies of three universities where interviews took place.

3) The Design of Interviews and Questionnaires

The design of interviews was administered on two separate occasions; the second round sought to clarify unclear responses from the first set of interviews. The first set of interviews was conducted during the Initial Study (at the University of Tripoli) and the

second was carried out during the formal study – more than 9 months after the first interviews, which gave the author a wider understanding of the changes that happened between the two stages of interviewing).

The question arises here as to why should such interviews be conducted in different periods? Saunders *et al.* argue that the validity and reliability of data depend, on the design and structure of questions, and the strictness of the pilot study (Saunders, et al., 2015). Using the process illustrated in Figure 8, the author followed the following steps to design the interviews. Here, we consider just the general process, while particular actions, such as translation between languages, are not considered:

- Initial interview design: in this step, the first draft of the interview questions was designed. These questions were based on the observations from the literature review and the international experiences of CD-ERP.
- Conduction of the initial study: the first interviews were held at the University of Tripoli.
- Improvement of the interview design: this step came after the initial study and a review of the current research progress, conducted with the project supervisors. Questions were redrafted and the content restructured to take into consideration all of the feedback.
- The interviews in the formal study: in this step, the revised questions were administered to representatives of the other two universities.
- Collection and analysis of data.

Figure 8: Protocol of the interview

4) Topics included

The topics included in both the interviews and the questionnaires can be categorized as follows:

- Information about an institution: To confirm basic data about a university, university profile, size, turnover, operations, and other general information.
- Institutional processes: To explore a university's main business processes and to determine secondary processes (sub-processes).
- Information systems: To establish the types of ISs implemented and to assess the underpinning technical architecture.
- Current status of the systems: To confirm the functionality of the main information systems and general levels of satisfaction in various departments that use them.

- Problems and challenges: To determine whether there were any key problems or issues, from both a technical perspective and the point of view of the end-user. The integration and interfacing of systems, quality of reports, systems performance, and access are some of the issues covered.

3.2.6. Documentation Review

A documentation review is a common method of collecting data by studying existing documents. These documents may be internal and/or external to a program or organization. Documents may also be in the form of a hard or an electronic copy. They may contain reports, program logs, performance ratings, funding proposals, minutes of meetings, newsletters, and marketing materials. (Yin, 2013) pointed out that a documentation review is one of the most important ways of gathering evidence from other sources, which is often relevant in case study research (Yin, 2013) (Denzin & Lincoln, 2000) (Silverman, 2004). The author would like to add that the documentation review was easier in the case of Libyan universities, since the author is a Libyan citizen and a staff member of The University of Tripoli. On the other hand, it was harder in some cases of the international organizations studied, due to these institutions being located in a variety of countries.

3.3. Target Population

Generally[1], this thesis studies CD-ERP projects related to academic services, since they are unique to HE. The case studies were limited to only three subjects, due to the civil instability in Libya. These subjects were chosen because (1) they are all Libyan public universities, (2) geographically, they are all located in the same region (Tripolitania Region) under the same regional government (3) they all require ICT development and (4) the author chose three different universities based on the size and history of each establishment. Such selection is consistent with the strategic and fair representation of Libyan universities. Libyan universities were first classified into three groups, and then the leading university from each group was chosen, In this context, UOT is considered to represent institutes with a long history in LHE, MU represents universities with a medium-length history, and SU is a relatively newly established university to represent other universities with similar history of establishment. These choices give a more comparative

[1] Specifically, the sample size and target population will be indicated for each case study separately in Chapter Six: Libyan Case Studies and Findings.

view and these three universities can be used as models of other universities. The case studies chosen are[1]:

Case Study 1: University of Tripoli (UOT)- Libya (Initial Study)
Case Study 2: Misurata University (MU) - Libya
Case Study 3: University of Sirte (SU) – Libya

Besides the previously mentioned reasons for choosing UOT to be the subject of the initial study, UOT has been contributing effectively to the establishment of many universities in Libya by providing consultants and educators. Hence, such contribution has led to similarities between those universities. The design of the data collection and analysis of the targeted population were both based on the concept of snowballing/respondent-driven sampling. Respondent-driven sampling is a popular method of data collection in the study of "hidden populations", such as the homeless or undocumented workers (Salganik & Heckathorn, 2004), or niche populations.

3.4. Sampling

A sample is a set of items that are selected, in one way or another, from the population. Methodologically speaking, a population, not to be confused with the everyday use of this term, is the total set of items that are being studied. These items can be humans, e.g. students and patients or non-humans, e.g. cities and technological events. A sample is the portion of a population that is observed. In everyday use, the term “population” is generally used with a specific group of people (Frankfort-Nachmias & Nachmias, 2008). In this research, it refers to the whole set of things or cases which are the subject of the research. In this research, two types of sampling are used, namely: snowball sampling and convenience sampling. Both of them are non-probabilistic methods of sampling.

Sampling can be generally divided into two methods; probabilistic sampling and non-probabilistic sampling. Probabilistic sampling (or random sampling) occurs when each member of the population has an equal chance of being selected as a member of the sample, while there is no specific probability of an individual being a member of the sample under non-probabilistic sampling. Under probabilistic sampling, participants are chosen at random from a list of the members of the population or to reflect the (known) structure of the population, e.g. according to demographic features. Non-probabilistic sampling is based on arbitrary selection with members of the population having different chances of being selected. The results from probabilistic sampling are unbiased, while non-probability sampling introduces a selection bias. Probabilistic sampling is preferred

[1] At the beginning of this research, three universities were chosen as cases studies based on their size and founding year. Later after conducting the initial study in which UOT works as one case, it was possible to decide whether or not to include more case studies of Libyan universities.

if the research is aimed to be conclusive, while non-probabilistic sampling can be advantageous when the research is exploratory, as in this study, when the author is trying to generate ideas and obtain feedback from participants. This is particularly true when it is advantageous to investigate specific members of the population, e.g. those who can be described as experts. Methods of probabilistic sampling include Simple Random Sampling, Stratified Sampling, Cluster Sampling, and Systematic Sampling. Convenience Sampling, Quota Sampling Judgment or Purposive Sampling and Snowball Sampling are methods of non-probabilistic sampling (Kalton, 1983) (Levy & Lemeshow, 2008) (Lohr, 1999) (Rea & Parker, 1992).

3.4.1. Convenience Sampling

Convenience sampling is a type of non-random sampling where members of the population who meet the criterion of being available at a given time or are willing to participate are included in a sample. Hence, any such sample is composed of members of the population that are easily accessible to the researcher (Dörnyei, 2007). Convenience sampling is sometimes called "accidental sampling", because elements may be selected to become members of the sample simply due to their location, spatially or administratively, close to the researcher conducting the data collection (Etikan, et al., 2016). Due to the specific nature of the group of people who are working on/familiar with ISs and the ERP approach in the Libyan context, the author chose to use this sampling type.

3.4.2. Snowball Sampling

Snowball sampling, also known as chain-referral sampling, of a hidden or niche population, is a non-probabilistic method of sampling. A hidden population is one where it is impossible to select a sample using probabilistic methods, e.g. no list of members of the population exists. The members of niche populations have very specific traits, but are strongly socially or professionally connected[1]. Snowball sampling begins with a suitable choice of (an) initial subject(s) as respondent(s). The initial respondent(s) serve as seed(s), through which wave 1 subjects are recruited by recommendation; wave 1 respondents, in turn, recruit wave 2 respondents, and the sample consequently expands wave after wave - like a snowball growing in size as it rolls down a hill (Etikan, et al., 2016). This process gives snowball sampling its name.

The use of snowball sampling in research on hidden or niche populations has created a widespread perception of snowball sampling in particular and chain referral methods in general as suitable sampling methods (Erickson, 1979)**.** One of the criticisms aimed at snowball sampling is that respondents regularly propose others who have similar

[1] In the literature there is no satisfactory definition of the concept of niche. In the biological literature, a niche can be defined as a component of a substructure of the ecosystem (Kroes, 1977).

characteristics. Hence, it is necessary to choose an initial set of sufficiently diverse respondents, to ensure that the sample is not excessively directed in any particular way.

3.4.3. Respondent-Driven Sampling (RDS)

RDS is a method for studying a population through the social networks of members of that population, as opposed to random sampling or a prearranged sample of a known group of individuals within the population. Using respondent-driven sampling, a researcher identifies one individual within a population as a "seed," collects data from the seed about the population, and obtains additional participants in the study based on the social network of the seed. After these additional participants have been identified and agreed to participate in the study, they, in turn, can serve as seeds for identifying yet more participants (Salganik & Heckathorn, 2004).

RDS combines "snowball sampling" (getting individuals to recommend those they know, these individuals, in turn, recommend those they know and so on) with a mathematical model that weights the sample to compensate for the fact that it was collected in a non-random way (Heckathorn, 2011). Also, similar to snowball sampling, initial seed respondents recruit additional respondents from their network of connections. The recruiting process repeats itself, thereby forming long referral chains. Unlike under snowball sampling, estimates of the size of each respondent's network are obtained. Hence, each respondent must be able to give an estimate of the size of their network (Schonlau & Liebau, 2012). Recruiting in RDS is, hence, driven by respondents rather than by interviewers. This feature gives RDS its name (Schonlau & Liebau, 2012).

3.4.4. Recruitment Strategy

Using RDS, a researcher identifies one individual within a population as a "seed," collects data from the seed about the population, and obtains additional participants in the study based on the social network of the seed. After these additional participants have been identified and agreed to participate in the study, they, in turn, can serve as seeds for identifying yet more participants. Thus, this snowballing of participants also illustrates the social network within a population (Salganik & Heckathorn, 2004).

The author used a method combining aspects of both snowball and RDS sampling. The author used the feature that each respondent is asked to give an estimate of the size of their network. This helped to decide whether to use interviews or questionnaires. This again depends on the estimated size of the network of the seed(s). Recruiting is driven by the interviewers rather than by respondents, as in snowball sampling.

3.5. Justifications for the Choice of Methods for Data Collection

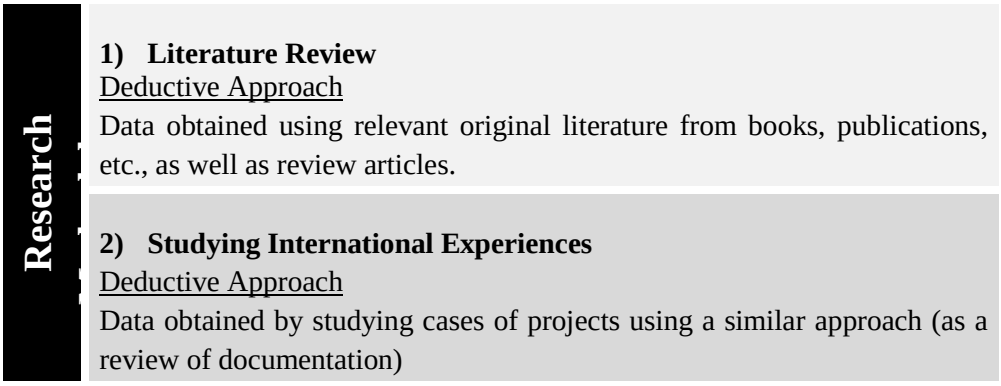
To increase the validity of the findings and confidence in the reliability of the information gathering, despite data collection being piloted prior to the main interviews,

the author used several methods of data collection, as described previously. A documentation review was used to ensure the validity and reliability of the research. Besides, the author revised the questions in the interviews and questionnaires (based on the initial study). To study the international experiences from such projects, cases were included from the documentation review and other sources that were cited accordingly.

3.6. Ethical Considerations

Research ethics provides guidelines for the responsible conduct of a study, as well as to control any research conducted, to ensure high ethical standards. The study was conducted according to the regulations of Wrocław University of Science and Technology for academic purposes only. Data were gathered from three main resources, fieldwork in Libya, a study of experiences from international projects and a review of the relevant literature. The latter was cited whenever needed, while the fieldwork in Libya was conducted with the consent of the Libyan universities involved and their IT staff who participated in the interviews. The names of the participants were coded for privacy. Finally, cases of international experiences were also cited whenever needed. The data and information provided in this work cannot be reused or copied by any means without the approval of the appropriate authorities or the author himself.

In short, Figure 9 below gives a summary of the methodology used in this thesis. Basically, this research is an introductory study to investigate the applicability to LHE of a community-source approach to developing ISs based on an ERP system. To build the proposed system, three main data resources were selected, namely: (1) a review of the relevant literature to understand the critical factors for successful adoption of this model, in which the following topics were covered: IS development with an emphasis on collaboratively-developed IS, ERP systems, multi-tenancy and cloud computing; (2) lessons learnt from international experiences, based on a number of selected cases; and, most importantly, (3) findings from the fieldwork in Libya in which three Libyan public universities were surveyed as a model.



3) Studying the Libyan Context

Analysis of Multiple Case Studies

Inductive Approach

Collection of Qualitative Data

Data obtained using interviews and reviews of documentation

Data analyzed on the basis of:

- Process mapping and system profiling techniques
- The CPIT model.
- The Stages of Growth theory
- Zuboff's model

4) Outlining a proposal for a collaborative system

Figure 9: Summary of the methodology used in the study.

3.7. Summary

In this chapter, the research methodology of the thesis has been discussed. Elements such as the research strategy, approach and philosophy have been described. As stated previously, three main sources of data were used, namely: a review of the relevant literature, international experiences (deductive) and fieldwork in Libya (inductive). A narrative literature review was used to draw conclusions about the topic of this thesis. Next, cases of other projects that follow a similar approach are included, as well as the lessons learnt will be described in the following chapter.

CHAPTER FOUR: INTERNATIONAL EXPERIENCES

4.1. Introduction

The term *collaboratively-developed* IS is not consistently used in relation to open-source software either in the literature or in practice. Many terms are used synonymously, including open-source software platform, open-source software community, open-source software projects, open-source software foundation, joint development and open-source software ecosystem (Liu & Qiang, 2011). To avoid any confusion, these terms are defined in this section of the research. Furthermore, the author briefly describes projects of this form that have been implemented in various countries, to better understand the concept of community-source.

It had been intended to study these cases using a deductive method based on quantitative data. The author contacted the directors of the international projects mentioned. They were then asked to complete online questionnaires based on the SERVQUAL model to gather the necessary data from the participants. Unfortunately, very few of them participated in this research. Instead, cases from various projects that follow a similar approach were included based on reviewing the documents received from them, such as feasibility study reports, with the support of available academic publications. Also, the author continued to contact the project leaders for further information and the leader of the USOS project was even interviewed in person. These additional sources of data from such international projects are valuable in giving this research a wider view. Finally, the author concludes with the lessons learnt from these cases and discusses their relevance to this research.

4.2. What Community-Source is all about

Generally, “community-based open source” is also described in short as “community source” and in this research is called “collaborative software development”. It was first proposed by Brad Wheeler and defined as a type of open source project that is governed by a group of educational institutions or even firms. In a community source project, a consortium of partners shares their financial efforts and human resources to complete a project. This project is managed through a typical model of consortium governance (Hanganu, 2008). Community source is an environment where each partner must view the other partners as non-competing, to share some of the costs and risk, as well as reaping the maximal potential reward (Wheeler & Hilton, 2012). The development of community source is considered to be a way of developing applications, resulting in a unique type of open-source cooperation involving collaboration from multiple organizations in a virtual environment (Liu & Qiang, 2011). Open-source solutions are software for which the source code is provided under a license that permits users to access, change, and improve it (Monarch, 2010).

Wheeler and Hilton differentiate between two terms with similar meanings that are associated with the principle of developing systems jointly: *cooperation* and *collaboration*. Cooperation is based on an agreement to abide by a set of common rules or principles, while collaboration requires a higher level of engagement and consideration of objectives. This distinction between cooperation and collaboration means that development and shared service communities can be classified into two basic types: *communities of cooperation*, such as Apache, Drupal, and Moodle and *communities of collaboration*, such as Kuali and Sakai. The former correspond to communities where principles and/or aspirations are shared among individual members who fundamentally retain their autonomy (independence), while the latter corresponds to a kind of community where a specific vision is shared and set. Communities of collaboration are created and sustained through a charter and governance system that explicitly sacrifices the independence of individual developers in favor of clearly defined roles. Collaborative communities come in many forms, while the collaboration lasts only as long as the specific goals and funding are in place (Wheeler & Hilton, 2012).

4.2.1. Parallels between Community Source and other Models

Courant and Griffiths call the community source model "collaborative directed open source projects", while they refer to "open source software" when software has an open-source code, without reference as to how it was produced (Courant & Griffiths, 2006). Therefore, the community source approach is described as a "borrowing path" which possesses the advantages of both buying ready-made software and constructing it. As community source is considered to be a middle way between open source and commercial packages, it raises a question regarding at which points does community source "meet" the characteristics of other models and when does it "differentiate from" them. On one hand, there are some points where the community model meets open source development, including a commitment to open-source code, the integrative role of shared values, widespread distribution of both knowledge and expertise and openness to multiple approaches (Liu, et al., 2015). One of the drawbacks of traditional open source is the unpredictable outcome of a project, while the development process under the community source model is monitored to achieve the final goal. Unlike community-source, contributions to code may not be included in the project source when following the traditional open-source model (Liu & Qiang, 2011). On the other hand, community source is close to commercial development in the sense that there exist formal partnerships between participating institutions and developers, institutional control of development processes and competition for access to development skills (Liu, et al., 2015).

4.2.2. Closed Community Source

As an alternative to community-source, some companies use the term closed community-source to refer to the licensing of a source code exclusively to members of a

pre-defined community, who can modify the code. For a given community source, the exclusivity of a community influences the development of a project during an initial, closed stage. After this closed period, the code can be made available to everyone, and its development moves towards a more traditional open-source model. In a closed community-source project, modified code can be shared within the community at all times, but cannot be made available to those outside the community. Each member of the community must explicitly enter an agreement with the code owner, to be permitted access to the source code. The main problem with this understanding of community-source is that the licenses proposed are incompatible with the requirements of the definition of open source. The following are examples of community-source licenses: the Sun Community Source License, Real Networks Community Source License and Microsoft Community License (Hanganu, 2008).

4.2.3. Components of Community-Source

All types of communities: cooperative, collaborative or closed, are made up of several key components, including 1) goal alignment, formed and sustained by the community; 2) sufficient resources, which are important for developing successful communities to achieve common goals, such as staff assigned to specific institutions, financial and other resources, and/or commercial support, and 3) shared values: communities need some minimal shared values to hold them together with common rights and privileges being afforded to colleges, universities, and commercial firms. Software licensing is another means for a community to define and express shared values to determine who owns these products and under what conditions they may be used, repurposed, combined, or sold (Wheeler & Hilton, 2012).

4.2.4. Strengths and Weaknesses of Community-Source

The literature highlights several benefits associated with community-source that can influence the development of an application, such as fast completion and deployment of a project, reductions in the total cost and minimization of the uncertainty regarding the value of a system. Partner institutions pool their resources to develop a system that gives institutions better control over software development (Liu & Qiang, 2011). Despite the weak points of commercial, in-house applications and open-source models, community source remains a complex endeavor, due to the diverse (or conflicting in some cases) requirements of various partners, as well as other issues related to joint development, such as security or communication (Liu, et al., 2014). Courant and Griffiths argue that the biggest potential payoff would be from correcting the coordination failures between users and developers in a more systematic way (Courant & Griffiths, 2006).

Another concern regarding community-source is the issue of governance. Indeed, such a project is managed through a typical model of consortium governance that reflects the complexity of the requirements of the various members. This issue has been mentioned

by various authors alongside the issue of code ownership. According to the above definition of community-source, the community exists as a closed unit until the application's release. Later, the source code will be available as a free open source. In such a case, the question arises as to why the founders should invest money in developing such code since it is going to be released as a free open source. As mentioned before, there is another kind of community-source, known as closed community-source, which is confined to a predefined group of participants. To help solve the question of governance for either a pure community-source project or a closed one, an organization to realize the project should be created, to promote the use of more uniform licensing practices and manage the risks of liability, as well as providing assistance and best practice. Also, it is recommended to have a contributions agreement to document that permission has been given for the use of the code developed (Courant & Griffiths, 2006).

The last point brings us to another concern. Wheeler and Hilton noted, as a natural part of the life-cycle of collaboration, that a change in goals or vision among the members of a collaborative community can easily change the community's level of cooperation, or even in some cases terminate the project (Wheeler & Hilton, 2012). Hanganu sees community-source as a transitional phase in large cross-institutional collaboration processes, rather than as a fixed model of software development. For example, Sakai started life as a community-source consortium, and then moved towards open source development and joined the Apereo Foundation in 2012. The Kuali project started out using community-source and then became a single-company open source project in 2014 that operates an Apache-style foundation model. In the US, only Duraspace - the organization that developed DSpace and Fedora - still uses a model similar to community-source (Feldstein, 2014) (Hanganu, 2008).

The issue of project management also becomes critical in developing a system successfully using the community-source paradigm. Although increasing the number of organizations in a community reduces costs and risks, it complicates the management of a community project (Liu & Qiang, 2011).

Due to substantial organizational and legal barriers, active leadership and collaboration in IT is very hard. Courant and Griffiths discuss another important point regarding several conditions that seem to enhance the success of a community-source project. They mention that building a system on existing code works at least fairly well, as was the case for Sakai and Kuali. It is argued that such adaptation can prevent long negotiations about basic architectural decisions, as well as increasing the likelihood that the project can achieve rapid success to prove its potential value (Courant & Griffiths, 2006). This supports the proposed approach, which is based on ERP. Such projects are likely to achieve early wins and thus build momentum.

4.3. International Examples of Community-Source

In this section, real-life projects based on the community-source paradigm are briefly discussed, in order to better understand this approach. These cases offer us a great opportunity to understand the research issues regarding a community-source project adopted in HE, as well as to confirm the observations from the literature review. Originally, the community-source paradigm was applied by the Kuali and Sakai projects in the United States. Implementations of similar projects in Europe, Asia, and Africa have also taken place including; development work on Sakai at both Cambridge and Oxford in the UK, and on Kuali at Strathmore University in Kenya, the Cineca Consortium in Italy, the Sigma Suite (a student information system) and the CRIS Argos Suite for research management in Spain, the FS University Consortium in Norway, the AMUE system in France, Ladok in Sweden, JISC and UCISA in the UK, Surf in the Netherlands, AXIES in Japan, ASAUDIT in South Africa, CUCCI in Canada and HisinOne in Germany.

4.3.1. Case Study of the Kuali Project – USA

Kuali is a comprehensive administrative software suite, created in 2004 as a solution for HE institutes. Initially, the Kuali project was to develop a baseline system for financial services. It was later expanded to include eight Kuali applications to work as an umbrella suite of administrative systems for HE (Liu, et al., 2015). Kuali uses a modular architecture based on Java (J2EE) and is delivered as Software-as-a-Service (SaaS) with a source code package available for onsite installation. The founding partners are Indiana University, University of Arizona, University of Hawaii, Michigan State University, San Joaquin Delta Community College, Cornell University, the National Council for College and University Business Officers (NACUBO), and rSmart. As of 2014, Kuali members include an international group of research universities, community colleges, and public and private institutions, with more than 70 development partners, including 12 commercial affiliates (Liu, et al., 2014) (KUALI, 2019).

1) Kuali Modules

From its initial focus on financial affairs, Kuali has expanded to include multiple system modules, including 1) research administration (Kuali Coeus); 2) student information management (Kuali Student); 3) library management (Kuali Open Library Environment); 4) business continuity (Kuali Ready); 5) human capital management (Kuali People Management for the Enterprise); 6) mobile device integration (Kuali Mobility) and 7) middleware/integration (Kuali Rice). For each Kuali module, a functional council, technical council, and project manager report to the Kuali board (Liu, et al., 2014) (Liu, et al., 2015).

2) Strengths and Weaknesses of Kuali

Both studies (Liu, et al., 2014) (Liu, et al., 2015) list benefits associated with the Kuali project that, in fact, reflect the benefits of community source. These benefits include 1) cost reduction and resource sharing: development partners reduce costs by sharing resources and insight, 2) independence: development partners avoid dependence on vendors and third-party system integrators, 3) system customization: development partners build the features they want into the system, 4) developer training: the personnel assigned by development partners gain expertise in platform design, maintenance, and 5) community involvement: development partners create strong social bonds through collaboration, establishing a supportive "family" atmosphere.

In terms of the challenges which are generally associated with the community-source model, these include limited access to talented developers, managing the levels of institutional commitment, coordinating across multiple regulatory regimes as the complexity of collaboration within and across projects increases, community governance, roles of commercial affiliation, cross-project knowledge sharing and the determination of pricing mechanisms. One particularly salient challenge in the case of Kuali is the management of growth. To handle the growth of the community, three forms of partnership: development, deployment, and sustaining, have evolved. Several of these challenges are linked to a low-level of integration and lack of cohesion/consistency within the community, a low-level of knowledge transfer within the broader community and a lack of effective interfaces between distinct developer groups, which all require improved project coordination to integrate diverse development teams (Liu, et al., 2014) (Liu, et al., 2015).

4.3.2. Case Study of the Sakai Project – USA

Sakai is another comprehensive administrative software suite designed as a solution for HE institutes, based on the community-source approach. It was first released to the public in 2005. The purpose of the project was to produce open-source Collaboration and Learning Environment (CLE) software. Sakai was developed based on a centrally-planned model, with the use of existing tools contributed by each of the founding institutions. The founding partners of Sakai are large US universities: University of Michigan, Stanford University, Massachusetts Institute of Technology (MIT), University of California, Berkeley (UC Berkeley), and Indiana University. It was funded by a Mellon Foundation grant. Today, it is managed by the Sakai Foundation, which oversees its development (Monarch, 2010) (Wei, et al., 2014) (Severance, *et al.*, 2007). In other words, the development of code is conducted by the Sakai community, but the organization which is responsible for defining the development guidelines is the Sakai Foundation (Alves, et al., 2012) (Sakaiproject, 2019).

The second generation of the Sakai Collaboration and Learning Environment is known as Sakai 3 or Sakai OAE (Open Academy Environment). It was developed with a new vision for academic collaboration in education and research. It has a Learning Management Services LMS application, but allows the community to expand beyond the boundaries of a single university (Ignjatovic & Jovanovic, 2013).

Sakai uses a modular architecture based on Java (J2EE) and is designed to be a service-oriented suite, allowing easy integration into a portfolio of organizational applications (Monarch, 2010). It consists of a two-layer application: the inner layer, called the kernel, constitutes the support services, and the external layer, whose components produce the features available to users (Alves, et al., 2012).

3) Sakai Modules

The Sakai platform covers any kind of activity requiring collaborative work within the institutions, including multiple system modules with administrative features, such as an Enterprise Services-based Portal, a complete Course Management System with sophisticated assessment tools (register, exams, and timetables), a Research Support Collaboration System: including the most common web-based tools for collaboration and communications, a Workflow Engine, and a Tool Portability Profile, as standard for writing future tools that can extend the core set of educational applications (Ignjatovic & Jovanovic, 2013).

4) Strengths and Weaknesses of Sakai

Some of the benefits associated with Sakai are listed in this section. First of all, Sakai's reputation comes from its higher-end features, scalability, and security, which have made it popular with large universities, as well as in the government and public sector markets (Monarch, 2010). Other benefits inherent in the community-source approach, such as lower overall cost, easier development and maintenance, flexibility to host and ease of customizations, should continue to be some of the main benefits of using Sakai (Francisco, et al., 2011).

In terms of challenges, Sakai lacks comprehensive competency profiling and management. It can also be challenging to integrate Sakai with other enterprise software systems, such as ERP. Besides, Sakai is challenging to install and set up, which makes it less suitable for simple, fast deployment projects that require Learning Management Services (LMS) (Monarch, 2010). This is confirmed by other authors, who emphasized that Sakai is too difficult to build for staff who are not experienced Java developers and too difficult to install for staff who are not sufficiently technical (Francisco, et al., 2011).

4.3.3. Case Study of the USOS Project and the MUCI Consortium– Poland

The University Study-Oriented System Project or "Uniwersytecki System Obslugi Studiow" (USOS/University SOS) is an integrated software system supporting the

management of higher education at university-level, generated by members of a Polish consortium known as the University Centre for Informatization (MUCI). This Project is achieved via the effective cooperation of Polish universities, working jointly to develop and deploy IT projects, including USOS, probably the best known of these systems. Currently, the members of the consortium include 50 Polish universities, technical universities, higher vocational institutions, university schools of physical education and other types of higher education institutions (USOS, 2019). Remarkably, during this project, graduate students have worked as programmers under the coordination and supervision of academic teachers who designed these sub-projects (Mincer-Daszkiewicz, 2002).

The history of USOS dates back to 1999-2001. USOS was released after the Conference of Rectors of Polish Universities in 2002 (Czerniak, 2010). Indeed, USOS was first created and deployed at the end of the Educational Tools Tempus JEP project[1] with limited functions, such as course catalogs or a database containing information about students and teachers. Soon, concerns about the future of USOS arose and in 2002 the MUCI consortium was created, since the Polish authorities had decided to follow the concept of the LADOK consortium of Swedish higher education institutions (USOS, 2019). MUCI is an open and non-profit organization that can be joined by any HE institute. MUCI was constructed to coordinate, support and initiate IT projects, such as USOS. These activities are: designing and developing ISs; setting regulations; collecting funds; representing consortium members in talks with the Polish Ministry of Education and negotiations with IT companies and vendors (USOS, 2019).

The Consortium Council and Board of Directors are the two governing bodies of MUCI. The former consists of all the members with equal voting rights, while the latter consists of only 5-11 members. The Board of Directors is responsible for the overall direction of activities; generating reports, such as budget proposals or annual reports, while the Consortium Council is responsible for accepting the reports generated by the board, as well as accepting new members and electing the board and its chairman. However, any group of MUCI members has the right to start a common project, supervised by Project Commissions that consist of representatives of the institutions willing to participate in a common project. USOS is one such project (USOS, 2019).

The structure of the MUCI is based on a business model in which the cost of system maintenance and development is covered by the membership fees. New members pay an initial fee and then annual fees are paid based on the budget of a project and the size of a

[1] The Tempus JEP project called New Educational Tools started in November 1999 and ended in December 2001. 17 Polish universities are members of this project, together with universities from UK, Belgium and Germany, as well as the Swedish LADOK consortium. The Tempus JEP project was to unify procedures at university level and develop a common Integrated Student Management Information System (SMIS) for academic structures and student affairs at Polish universities.

member. This means that even small organizations can join a project. In return, members obtain fully operational ISs, including all their subsystems and modules, and support. Source code is available on-demand for institutions participating in the project with no limits on end-users or installations (USOS, 2019).

USOS and its subsystems are installed locally at each member university and the headquarters of USOS is the Faculty of Mathematics, Computer Science and Mechanics at the University of Warsaw. The USOS project is considered to be long-term, since needs, legal changes and priorities are reexamined continuously, which reflects the development of information technologies (USOS, 2019).

5) USOS Modules

Originally, when it was first deployed in 2000, the USOS modules were limited to the main business activities of HE at university level, such as supporting student affairs in general, course catalogs, course registration, class schedules, data regarding students and teachers, study programs and requirements for degree certificates. Subsystems for handling financial affairs were added later, such as records on student grants and tuition (Mincer-Daszkiewicz, 2003) (USOS, 2019). After Poland became a member of the European Union (EU) in 2004, USOS supported the ECTS credit system and diploma supplements[1]. English language interfaces were also enabled, as well as functions facilitating student mobility inside Europe, in 2007 (Czerniak, 2010) (USOS, 2019).

Moreover, USOS was integrated with an e-learning platform based on Moodle. The web-based central admission system (IRK) used by the University of Warsaw was added to USOS modules in 2005. In 2005, a user-friendly authorization and authentication system was also included by adding the CUS system and, later, the CAS system. After the introduction of electronic student identity cards in Polish universities in 2006, USOS has also facilitated these electronic cards, printers, readers, and digital signatures from various vendors. Besides this, USOS offers data and statistics to members (USOS, 2019).

The first web-based student and academic-centered user interface was introduced to USOSweb modules in 2003, allowing several online services, such as records of students' results and achievements and on-line questionnaires on the teaching process. Moreover, the central Registry for Results of High School Examinations, which was deployed in 2006, allows universities that signed an agreement with the University of Warsaw to obtain data on candidates essential to the recruitment process. Also, the Course and Diploma Catalog was first deployed in 2006. These systems are fully compliant with the requirements of the Bologna Declaration (Czerniak, 2010). The Career Office module was

[1] The European Credit Transfer System (abbreviated to ECTS) is a credit system designed to make it easier for students to move between different countries. It is a central tool in the Bologna Process, which aims to make national systems more compatible.

deployed in 2008. In 2010, SRS systems were added to USOS for booking classrooms for classes and other events (USOS, 2019).

6) Strengths and Weaknesses of USOS

The USOS system was produced in-house. One of its strengths is that the annual fees are very low and all the funds collected are spent on application development (Mincer-Daszkiewicz, 2003). Also, the online modules of USOS (USOSweb) can be integrated with departmental portals (Mincer-Daszkiewicz, 2002). Although USOS is following a closed community-source approach that is open just to participating members, the principles and methods of software development are similar to those used in open-source projects (Czerniak, 2010). Furthermore, statistics and data are gathered from many HEIs into one system, which helps in the process of decision-making. Another important point in favor of the USOS project is that staff who develop or deploy the system receive the help and support of colleagues from other universities in solving technical and organizational problems (Mincer-Daszkiewicz, 2003). Besides this, developers have the support of scientific staff in the university environment, where they are developing new algorithms and solutions (Czerniak, 2010). The last point brings us to a drawback of USOS. Although development in a university environment is beneficial, salaries at universities cannot compete with those of industrial or software companies. Also, such a project demands much greater involvement from academic staff, substantially exceeding ordinary academic obligations (Mincer-Daszkiewicz, 2002).

As mentioned previously, graduate students have been involved in writing code. Only prototype versions of selected modules have been developed by graduate students. This allows them to gain experience, lowers the cost of developing newer modules and supports the development of the system in an academic environment. However, students are not fully productive during summer breaks or exams (Czerniak, 2010) (Mincer-Daszkiewicz, 2002). Czerniak mentioned other challenges, such as difficulties in developing better tools for data mining and visualization; the need for USOS to have better integration and data exchange with other university information systems; challenges to maintaining an online service (the system is available 24 hours a day) and parts of USOS are projected to be rewritten in the case of introducing a new technology platform (Czerniak, 2010).

4.3.4. Case Study of the Oodi Project – Finland

This section considers another case based on a feasibility report conducted by the University of Tampere in 2012. There have been several attempts to follow a community-source approach, either in individual projects run by universities or joint projects under the Finnish Ministry of Education and Culture. The Oodi Consortium is the most significant organization nationally in the field of developing student information systems. The administration of the Oodi system has been centralized into the Oodi development unit. The Oodi system was launched in 1995. Oodi consists of two versions: WinOodi,

which is the administrators' user interface, and WebOodi, which is used by students and teachers. The founding partners are the University of Helsinki, Helsinki School of Economics, Helsinki University of Technology, University of Oulu and Sibelius Academy. Presently, the consortium comprises 10 universities, namely: Aalto University, University of Helsinki, University of Eastern Finland, University of Lapland, Lappeenranta University of Technology, University of Oulu, Sibelius Academy, Hanken School of Economics, Theatre Academy Helsinki and University of Vaasa (Feasibility-study, 2012) (Oodi, 2019).

From both a technical and functional perspective, the weaknesses of Oodi have been pointed out by several studies. Oodi has complex and inconsistent technological architecture. Only software developers who are Finnish-speakers can adapt the Oodi source code, since it is written in Finnish. Other programming difficulties exist, such as outdated technologies and security concerns. In conclusion, it has been concluded that Oodi is a system at the end of its life cycle and in need of full renewal of its technological architecture (Feasibility-study, 2012).

The Finnish Ministry of Education and Culture realized the need to update student information systems, especially through closer cooperation between institutes. In 2007-2008, several studies recommended that universities should create a common base system, to phase out all of their technologically outdated base systems. Later, the Finnish Ministry of Education and Culture and HE institutions launched the Raketti project to implement ISs supporting HE services, as well as a national data warehouse for institutions. In particular, and most relevant to this research's area of interest, the objective of the second subproject (Raketti-OPI) was to create a common information system for all HE institutions. Although the resources allocated to the Raketti project for preparing a specification of requirements were insufficient, the Raketti project is likely to remain a key forum for cooperation between HE institutions in Finland. Besides this project, there are other joint development projects, such as the TIPTOP project and the ROTI project (Feasibility-study, 2012).

4.3.5. Case Study of the CINECA Consortium – Italy

Cineca is another project that follows the community-source approach. Cineca is a nonprofit consortium of Italian universities and research institutions, formed in 1969. Today, Cineca's membership includes 67 Italian universities, 9 Research Institutions, and the Italian Ministry of Education, University and Research. Cineca is led by several directors, namely: representatives (most commonly rectors) from each university and a public body which is a member of the consortium, as well as a delegate from the Italian Ministry of Education, University and Research (CINECA, 2019).

Cineca provides high-performance computing (HPC) services to both universities and the ministry. Namely, it provides hardware resources, software programs, and an efficient network to enable local and external communication, as well as qualified staff

members and expertise that can help scientists and researchers both technologically and scientifically. Moreover, it also provides hosting and system management, as well as code optimization and parallelization. Furthermore, it supports academic services, such as student management, course management, research management, governance control, planning and promoting education, national assessment of research, the administration of national research grants, and financial control of public funds (CINECA, 2019).

In terms of ISs, Cineca's CRIS (Current Research Information System), named IRIS (Institutional Research Information System), is currently running in 65 Italian Universities and Research Centers. Besides this, Cineca is involved in two official committees of the open-source community that has developed the DSpace Institutional Repository. In this role, it has developed (and released as open-source software) a solution named DSpace-CRIS that extends the functionality of the repository to the CRIS system based on the CERIF data model (CINECA, 2019) (Vertiv, 2018). The KION company was founded in 1999 and is responsible for developing and maintaining the student information system. This company has sold services to Turkey intending to expand into the European market. In a study conducted on Finnish Universities, the Cineca project was considered to be a suitable object for benchmarking, should incorporation become a topical issue in Finland (Feasibility-study, 2012).

4.3.6. Case Study of the LADOK Project – Sweden

LADOK, or LADOK NOVAU, is owned by a consortium of 37 Swedish HE institutions, while the maintenance of the "mutual core" of the LADOK system is the responsibility of a maintenance group at the University of Umea. LADOK is a computer-based student admission and documentation system for both universities and colleges. Its focus is on the administration of undergraduate/graduate studies. LADOK is utilized by all Swedish Universities. The system is deployed and managed locally by each institution, including the financing and maintenance of servers, networking, terminal equipment, and local support (Paulsen, 2002). National cooperation in the development of the Ladok system dates back to the 1970s. Over the years, the ministry has played various roles in steering the development of these information systems. At present, the ministry steers activities mainly through educational policy and by providing the information required (Feasibility-study, 2012).

The LADOK system is based on two integrated main modules, namely: the admission system, and the documentation system. Data from LADOK are exported to the Ministry of Education and other agencies for follow-up purposes. The LADOK system has a "mutual core containing databases and computer programs". Each institution decides which parts of the "mutual core" it wishes to use, while it is also possible to use locally developed addendums (Paulsen, 2002).

A summary of the projects described above is presented in Table **9**.

Table 9: Summary of International Experiences- Source: author's collection

Name of the Project	Founded	Initiator of the project	Source of funding	Present governing members	Features
Kuali Project – USA	2004	public and non-profit consortium consisting of Indiana University, the University of Arizona, the University of Hawaii, Michigan State University, San Joaquin Delta Community College, Cornell University, NACUBO, and the rSmart Group	membership fees and dues	representatives of 74 member institutions, the Kuali Foundation	• modular architecture based on Java (J2EE) • managed by the Kuali Foundation and became a single-company open-source project in 2014
Sakai Project – USA	2005	public and non-profit consortium consisting of the University of Michigan, Stanford University, Massachusetts Institute of Technology (MIT), University of California, Berkeley (UC Berkeley), and Indiana University. It was funded by a Mellon Foundation grant.	membership fees and dues	representatives of 74 member institutions, coordinated by the Apereo Foundation	• modular architecture based on Java (J2EE) • developed on a centrally-planned model • moved towards open-source development and joined the Apereo Foundation in 2012 commercially affiliated to develop, host, and support Sakai
The USOS Project and the MUCI Consortium – Poland	2002	17 Polish public universities	membership fees and dues	representatives of 50 different HE institutions in Poland	• the USOS Project is governed by a commission of MUCI members. • system development is driven by user needs which are reported daily to system developers. • based on a centralized Oracle database
Oodi Project – Finland	1995	public and non-profit consortium consisting of University of Helsinki, Helsinki School of Economics, Helsinki University of Technology, University of Oulu and Sibelius Academy.	consortium fees collected from the member universities	representatives of 9 member institutions	• used by the majority of Finnish universities • the Oodi consortium is responsible for maintaining and developing the system
CINECA Consortium – Italy	1969	non-profit consortium of Italian universities and research institutions	membership fees and dues	representatives of 67 Italian universities, 9 research institutions, and the Italian Ministry of Education, University and Research	• The Quality Management System of Cineca has complied with the international ISO 9001 standard since November 2001.
LADOK Project – Sweden	1970	non-profit consortium of Swedish public universities	membership fees	representatives of 37 members HEIs in Sweden (almost all of the HEIs in Sweden)	• modular architecture based on Java (J2EE5) • DB2 database

4.3.7. Other Cases of Community-Source

The author could not find sufficient information describing other cases of the application of community-source, especially on their technological status. Most of the information regarding such projects is not in English and unpublished. This indicates that very little attention has been paid to the community-source approach in the literature. Despite this, a brief overview of other cases is provided.

1) Case Study of the SIGMA Consortium – Spain

SIGMA is a nonprofit consortium that is analogous to Cineca. With a market share of 17%, the SIGMA Student Information System is used in 20% of Spanish public universities (Feasibility-study, 2012). It was established in 1996 by a group of 8 Spanish public universities to provide technological solutions based on their needs, as well as to develop a common student information system "SIS" and a research information management system "ARGOS CRIS" (Cuni, 2014). The solutions offered by Sigma are available on a Cloud and aim to help HE institutions to optimize their academic and research management systems by using best practice (SIGMA, 2019).

Sigma uses a modular architecture based on Java (J2EE5) certified application servers compliant with a multitier and high performance open architecture and delivered as SaaS (Cuni, 2014). The Sigma modules include: Sigma Academic, which provides stakeholders with the tools they need to complete Academic tasks; Sigma Research offers a very configurable system to support the research lifecycle; Sigma E-Learning helps interaction between teachers and students; Sigma Open Analytics provides appropriate tools for decision-makers to analyze information; Sigma Academic Mobile provides mobile apps to improve the interaction between students, institutions, and teachers (SIGMA, 2019).

The new University Services Consortium of Catalonia (CSUC) is another project related to the Sigma Consortium. It was established in 2012 by the Catalan Government and 10 public universities. However, Sigma provides a CRIS solution for three Catalan public universities. To accomplish the objectives of CSUC, these systems have to be compliant with the CRIS systems installed in Catalan universities. They provide mechanisms to integrate information from various CRISs in a central database, which facilitates the information flow. This avoids the problem of information duplication, as well as providing services to the community (Cuni, 2014).

2) Case Study of the FS Consortium – Norway

The Common Student System (Felles StudentSystem, abbreviated to FS) is a computer-based student administration system developed for Norwegian Universities, scientific colleges, and national university colleges. FS has been developed by an organization named Unit (The Norwegian Directorate for ICT and Joint Services in Higher

Education and Research). The development of FS is based on an in-house approach. It has been implemented in 35 institutions (Consortium, 2019). The FS project was financed by the Norwegian Ministry of Education and Research, and all publicly-financed educational institutions have the right to access to the system. The costs of maintenance and further development are shared between participant institutions (Paulsen, 2002). There are 14 different modules in FS, such as enrolment, term registration, payment, courses and programs, as well as an application reporting to the Ministry of Education and Research, State Educational Loan Fund and Statistics Norway (Consortium, 2019).

3) Case Study of the HISinOne Project – Germany

Another example of using a collaborative development approach in HE comes from Germany. The "Hochschul Informations System GmbH - HIS" (HIS-eG) is a non-profit consortium, aimed at creating an integrated management system, together with other IT solutions, consulting and expertise for universities and relevant decision-makers. Since its foundation, it has been considered to be an all-encompassing system for German universities (HISinONE, 2019). 70% of universities in Germany use HISinOne solutions with standard modules (e.g. an SIS and an HR system), as well as specialized configurations and adaptions (Hubner, et al., 2008).

HIS-eG is funded by its members. Members can order services from the cooperative directly as an in-house package (HISinONE, 2019). Its popularity in Germany comes from being minimal vendor lock-in, open design, open interface and community open-source. Hence, it does not function as a formal open-source license, since the source code and its documentation are only available to the community (Hubner, et al., 2008). As stated on their website, this cooperative principle is unique to the German HE landscape and has developed into a successful model. In addition to being able to access all HIS products, member universities can participate in various ways in the development process of HIS-eG (HISinONE, 2019).

The HIS-eG project follows a structure based on three main aspects, namely: 1) the General Assembly: this is the central body of HIS-eG, whose members are informed about current software developments, take formal decisions and elect the Supervisory Board and the members of advisory groups; 2) the Supervisory Board and Management Board: the Supervisory Board is the controlling body of the consortium, while the Management Board manages the business matters of HIS-eG and makes final decisions on product planning and business policy in close deliberation with the consultants of HIS-eG; 3) Advisory Boards: these are committees supporting the Management Board in decisions regarding product development and planning releases, as well as the strategic direction of HIS-eG. As a result of this structure, it is claimed that the requirements of universities are incorporated into software development and business policy at an early stage. Universities thus receive the greatest possible planning security concerning the pricing model, availability and stability of HIS software (HISinONE, 2019).

To guarantee that development would not slow down too much, "Development and Early Adoption Partners" were created. These partners consist of a number of universities acting as a (HIS) core team. The literature indicates that the requirements of community projects are more challenging than for non-distributed projects (Hubner, et al., 2008). Creating core teams is a way of enabling such communication.

4) Case Study of the AMUE Consortium – France

In 1992, French universities established the non-profit consortium that provided the main administrative systems needed in HE. It is called "Agence de Modernisation des Universités" (AMUE, The French Agency of National University Modernization). Most French Universities are members of AMUE (180 members, including universities and research institutions). AMUE is funded by both the state and its member institutions. Technically, AMUE provides core software applications to its members, such as student, financial and personnel management systems, which are designed using the Oracle client/server technology. Also, AMUE provides consultants for members in terms of IT, management, and professional development (Desnos, 2001). Besides this, it organizes cooperation between the participant members and supports their joint work. It builds a collective approach in consultation with experts from all of the 180 member institutions, from defining needs, choosing and developing IT solutions, to training and procurement (AMUE, 2019).

Similarly to the HIS-eG project, AMUE is organized based on three main pillars, namely: 1) the Management Committee: representatives from the HE community set the directions for development which are validated by the Conference of University Presidents and then constitute the frame of reference of the agency's activities; 2) Services proposed by university representatives during meetings that allow them to exchange their experiences, to pose questions and from that, to establish a collective goal; 3) Products that allow information and management systems to be securely installed in each institution to improve working conditions (AMUE, 2019).

4.4. Summary

As we can see, community-source has been adopted by many universities and government bodies worldwide. This raises the question as to what makes community-source (or collaborative development, as it is called in this research) widely popular, particularly among HE institutes. Traditionally, HE is a sector based on knowledge sharing. From this point of view, community-source is considered as a means of knowledge sharing alongside other means of sharing, such as sharing costs or human resources. As a result, community-source was described as a "perfect fit" to the philosophy and standards of research and education. Moreover, based on the cases described above, it is clear that collaborative approaches to developing applications can give results which meet the needs of the participating institutions, as well as the greater

potential to benefit the broader community, especially when we see that some cases in the HE sector have a fairly robust tradition of building their own software, such as Kuali or CINECA. Besides, community source is projected to overcome the historically encountered gap between software producers and the HE sector. Indeed, the HE sector is considered to be a unique environment with complex and poorly understood requirements, as argued in many places in this research. In the following chapter, the author discusses defining of the variables, development of the hypotheses and the assessment framework used to evaluate the level of ISs implemented in the case studies, as well as their readiness to develop their systems.

CHAPTER FIVE: HYPOTHESES AND ASSESSMENT FRAMEWORK

5.1. Introduction

Previously, a literature review was conducted on the factors considered in the conceptual framework of this study. Indeed, the author investigated the basic elements of the CD-ERP approach and compared them to other available technologies. This is because the topic of this research is quite new, and very few related studies have been conducted (to the author's knowledge). Also, some cases of international experiences have been included. This investigation led to an insight into approaches to system development and their strengths and weaknesses in the context of a collaborative approach. Within this frame of reference, a number of hypotheses are listed as shown in the following subsection, as well as how these hypotheses were developed. Also, the variables of the study are defined. The assessment framework used to test these hypotheses is discussed as well. The terms and models used in the assessment are also explained.

5.2. Defining the Variables

The term variable is perhaps the most used word in the terminology of scientific research. In any research project, there are variables that are subject to measurement in order to test the hypotheses of the study and to answer the research questions. A variable may be seen as a property of some object (e.g. its colour, the height of an individual). Generally, there are two main kinds of variables, namely: independent and dependent variables. As research methods became more advanced, another kind of variable appeared in the form of intervening/mediating variables (Cohen, et al., 2007). Independent variables are chosen by researchers (and often controlled by them) to explain the behavior of a dependent variable. In other words, a cause-and-effect relation is assumed between the independent variables (the causes), and the dependent variable (the effect). The goal of such a study is often to describe the relation between the independent variables and the dependent variable. (Denzin & Lincoln, 2000). Intervening/Mediating variable is a term that was used first by Tolman to describe a variable that plays a causal link between both the independent and dependent variables. In other words, it could change the relation between the independent and dependent variables. In fact, the presence of such a variable affects the expected relation between the independent variables and the dependent variable. Such a variable may be interpreted as an independent variable. However, today, the term moderating variable is widely used to describe such a variable (Cohen, et al., 2007) (Crotty, 1998).

Based on the formulation of this research, a classification into independent and dependent variables may be carried out. A collaboratively-developed university IS should be defined as the independent variable, since the goal is to investigate the "applicability" of such a system to LHE. From this point of view, the dependent variable is LHE in which

the technological and management capabilities of LHE are to be used as determining factors (determinants) that indicate the level of applicability. In other words, this study will attempt to measure the relation (in the form of the applicability of such a system) between collaboratively-developed university systems and LHE using Libyan universities as a model. Furthermore, ERP is a moderating variable that is independent by nature. ERP may modulate the relation between the other two variables, as it is may prove useful in solving the expected barrier of building a system from scratch in the case of LHE[1]. This investigation will be carried out via the assessment framework described below in order to test the hypotheses presented in the following sub-section, as well as to partially answer the research questions stated at the beginning of the thesis.

5.3. Development of the Hypotheses

After conducting a literature review, researchers usually make some hypotheses and predictions about the expected results from their studies. In this study, the author seeks to test the following hypotheses:

FIRST: Libyan universities can benefit from introducing integrated university systems, developed using a collaborative approach.

As mentioned in Section 2.5.3 in the conceptual framework, the level of collaboration among HE institutes in general and universities in particular is systemically increasing. Such collaboration can take many forms, including: research, teaching, human resource development, technological innovations, academic programs, and financial resources. Collaboration between HE institutes has long been part of accepted practice. ICT is also a means by which HE institutes can create leading-edge infrastructures and a free exchange of knowledge and experience (Malcolm, 2010). As a form of ICT collaboration between HE institutes, the observations from international experiences have shown benefits that can be gained through following a collaborative approach. For instance, this approach is projected to enable higher productivity and quality at a lower cost, create a pool of locally available skilled resources, leading-edge infrastructures and gather data from all HE institutes at national level under the Ministry of Education (Shrivastava & Date, 2010). Moreover, HE is a sector based on knowledge sharing and collaborative development is described as a "perfect fit" for HE. Indeed, a model based on community-source can be viewed as a means of knowledge sharing, alongside other means of sharing, such as sharing costs or human resources (Liu, et al., 2014) (Liu, et al., 2015). Also,

[1] Other aspects such as Cloud technology and multi-tenancy are not specifically considered as variables, since they are separate subjects from the collaborative approach itself. However, they are considered in the conceptual framework of this study, since it was observed, for example, that Cloud technology brings advantages to universities participating in a consortium by reducing the cost of investment in equipment and human resources. This has led consortiums to incorporate Cloud technology as one of the requirements of a collaborative approach or other systems recently adopted by universities/organizations.

consortiums of universities (i.e. based on a collaborative approach) have existed for a long time, such as the CINECA project in Italy which dates back to 1969 (Vertiv, 2018), while the community-source paradigm was first applied and officially introduced by the KUALI and SAKAI projects in the United States (Liu, et al., 2015) (Alves, et al., 2012), (Ignjatovic & Jovanovic, 2013). Other similar projects have been deployed in a variety of universities worldwide. This indicates the success of such an approach. Furthermore, Sakai and Kuali have reported a large number of implementations, both locally in the US and internationally. Many institutes have asked to join these two projects, which reflects the fact that the Kuali and Sakai projects are based on a successful model (Wheeler & Hilton, 2012) (Hanganu, 2008) (Feldstein, 2014). Accordingly, Libyan universities can benefit from introducing integrated university systems, developed using a collaborative approach.

SECOND: ERP should be used as a base for the collaboratively-developed integrated university systems.

As mentioned in *Chapter Four,* the international experiences indicate that building a system on an existing code that already works at least fairly well is a successful approach, which would save time negotiating about basic elements (Courant & Griffiths, 2006). Some international projects have faced difficulties in integrating their own systems with packages such as ERP. These projects did not restructure their systems to include ERP, since the costs of the process of rebuilding these systems using such technologies may exceed the expected benefits. Although various applications have been adopted by the HE sector, an emphasis on ERP implementations in this sector might be questioned. Even considering the difficulties and risks, the last decade has seen a remarkable worldwide expansion of ERP systems into HE. Without a doubt, ERP systems have played a substantial role in the development of IT in HE (Noaman & Ahmed, 2015). According to Rani, ERP systems are the most complex software applications adopted by universities and are accompanied by significant investments in their implementation (Rani, 2016). HE institutes are reported to have spent more than $5 billion on investments in ERP during the last few years (Seo, 2013).[1] This is another side of parallels and divergences of the CD-ERP model with other similar models. Indeed, the CD-ERP model is based on ERP to avoid the reconstruction of systems from scratch as recommended by international experiences, while it differs from projects that have built their systems on existing code (non-ERP). Such projects tend to have difficulties integrating with ERP. Another observation comes from the fact that the leader of USOS expressed that if there had been the chance to build the USOS project using such technology as ERP and multi-tenancy when they started the project, they would have done so. On the other hand, the author mentioned in the statement of the problem that the high establishment and operational

[1] For further discussion, please refer to Section 2.3.6 “ERP in Higher Education (HE)”

costs in ERP implementation present a major disadvantage if Libyan universities were to adopt ERP as a base. Based on the summary of failure factors of ERP given in Section 2.3.5, 28 out of the 34 failure factors are related to managerial aspects[1], not the ERP software itself. Moreover, none of the technical factors listed, apart from the one given by (Rani, 2016), "ERP are difficult to learn and use, with a complicated user interface", are directly related to ERP systems themselves. This confirms that ERP software itself is not a major cause of unsuccessful implementation. Also, the disadvantage of high establishment and operational costs should theoretically be avoided by following a collaborative approach, which leads to sharing such costs. Hence, Libyan universities would avoid building their systems from scratch by adopting ERP solutions as a base for the collaboratively-developed integrated university systems.

5.4. Testing the Hypotheses

In this section, the author discusses how the previously mentioned hypotheses will be tested. Speaking practically, these hypotheses also stem from the author's own experience in UOT in which ISs (both in-house and commercial models) are a critical issue. Theoretically, the ISs currently implemented in UOT might arguably be at a low-level of advancement, and a similar situation might also hold in the majority of Libyan universities. The expected lack of advanced ISs in Libyan universities, together with the similarity between these universities, may even be a benefit. It does give the opportunity to consider innovative solutions, including various modes of collaboration. In this context, the author is seeking to test implicit assumptions that the ISs implemented in Libyan universities are at a low-level of advancement (whether adopted or in-house solutions), and there is a lack of development capabilities at the level of individual universities. In other words, the effectiveness and level of advancement of the ISs (both in-house and commercial) implemented in Libyan universities will be considered as determining factors (determinants). Besides this, it is necessary to assess the level of expertise of employees specializing in IS development in individual universities (capabilities for developing ISs) as an additional determining factor (determinant). These determining factors (determinants) should together indicate whether or not the adoption of such a collaborative approach could be easier to follow and serve LHE better.

[1] For more details, refer to Table 3: Summary of factors leading to unsuccessful ERP implementation.

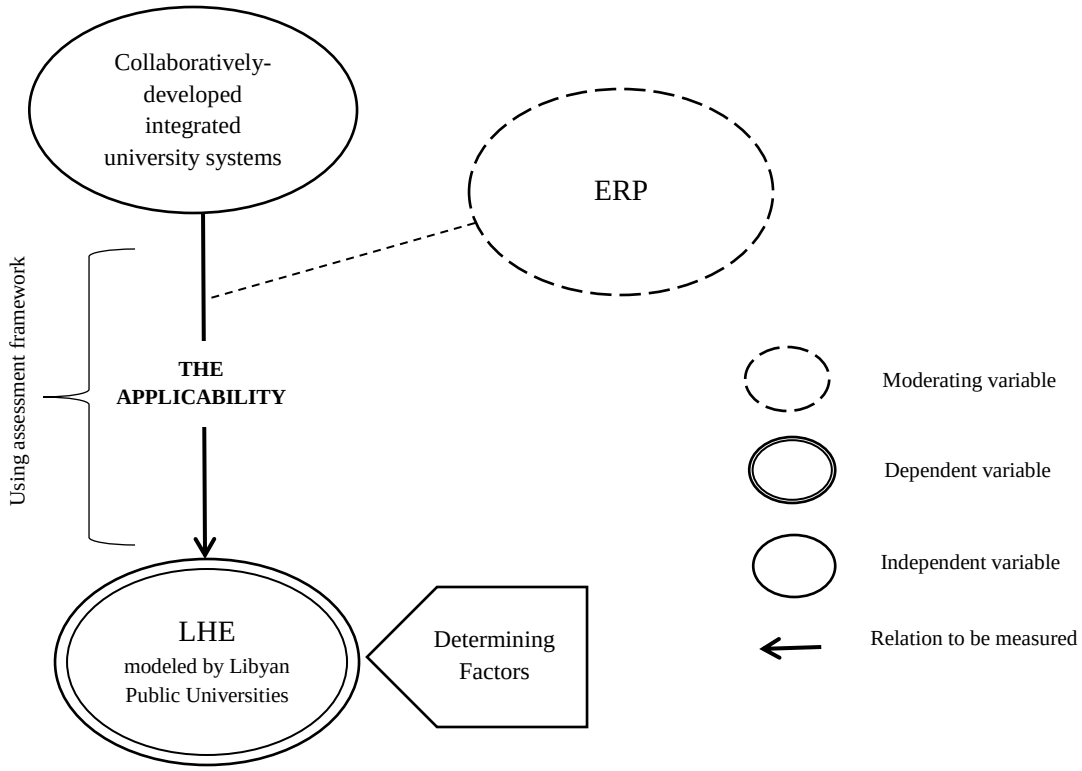


Figure 10: The overall hypothetical model for the study

Based on the above discussion, Figure 10 summarizes the hypothetical model for the study. Accordingly, the first hypothesis will be partially tested by assessing the level of the ISs implemented in Libyan universities. If these ISs are assessed to be at a low-level of advancement and potential for the development of an integrated IS only exists at the level of LHE as a whole, this would reflect the possible benefits of introducing collaboratively-developed integrated systems. If the first hypothesis is found to be reasonable, the second one will have at least been automatically and partially tested. Certainly, it is time and cost consuming to start building a new system from scratch. As previously-mentioned international experiences indicate that system development should be based on existing code, ERP is a promising solution. At the end of the study, the author will also discuss what forms of collaboration would be easiest to implement and better serve Libyan universities. To put it another way, the author will attempt to suggest an answer to the following question: "If Libyan universities are to adopt a collaborative approach, how can this be achieved? What are the benefits and what are the risks?"

5.5. The Assessment Framework

The evaluation of ISs is a process whereby organizations systematically assess the performance, value, or success of their ISs. Naturally, ISs are difficult to evaluate. In both research and practice, diverse approaches to evaluation and assessment measures have appeared (Zhang, 2015). In this chapter, the instruments used to assess the ISs

implemented in the case studies are discussed. These instruments are mainly based on the assessment framework developed by (Akeel, et al., 2013) with some modifications to suit the unique nature of this research. Also, some of the terms used are explained. In addition, the models and techniques used in these instruments are presented. The aim is to present the theory behind these models with enough precision to assist those who wish to use them in the future. Some of these models, such as Zuboff's Theory and Nolan's Model, are from classical studies. As in any field, classical studies play a vital role in ISs.

5.5.1. Objectives of the Assessment

The essential objectives of this assessment are to evaluate the level of the ISs implemented in the case studies and examine the capabilities of these universities to develop their own systems individually. The first of these goals relates to all of the ISs implemented in the case studies, regardless of whether they are locally developed (in-house) applications or commercial solutions. The second goal focuses on the in-house applications developed locally to assess the capabilities of the universities to develop ISs. The reason behind this evaluation is to test the hypotheses of this research regarding a) the low-level of ISs implemented in Libyan universities and b) the lack of capability for IS development within Libyan universities, especially when they work separately.

5.5.2. Dictionary of Terms

In this section, the meanings of the terms used in the context of this research is described in Table 10 below.

Table 10: Dictionary of terms for the assessment framework

Term	Description
Information System (IS)	The term "IS" covers all the kinds of ISs implemented in the case studies, whether they are in-house or commercial applications. However, this term is limited to the ISs associated with business processes (educational activities, research activities, and other business activities).
Applicability	The quality of being relevant or appropriate. The applicability of the collaborative approach for LHE is to be investigated, using Libyan universities as a model.
Level of ISs	The term "level of ISs" reflects IS performance in terms of functionality. This can be measured by the assessment of ISs currently implemented within the case studies ("Libyan universities") according to the assessment criteria.
Assessment of ISs	A procedure for evaluating the success of ISs in achieving their objectives.
Assessment criteria	The assessment criteria are designed to evaluate the performance of ISs in facilitating universities' business processes. These criteria include; the adequacy of these systems; the level of integration of these systems; their level of technology; the possibility of

	implementing commercial open-source software; and the availability of online content (Platiša & Balaban, 2009) (Palmius, 2007) (Chandler, 1982).
Performance of ISs	The extent to which these systems are simple to use; the extent to which these systems meet the needs of users; the efficiency of reports, as well as the reliability of the information provided and its support in decision making.
Adequacy of ISs	The extent to which these systems cover all business activities.
Level of integration	The extent to which these systems are integrated and communicate.
Level of technology	The extent to which these systems are built using up-to-date technologies.
Availability of online content	The extent to which these systems are available online.
Capability for IS development	The extent to which these universities are capable of developing in-house applications based on international standards, with an emphasis on working separately.
HE institutes	HE institutes include all forms of education beyond compulsory education, such as universities, community colleges, research/academic centers, vocational/technical colleges.
Universities	Universities are HE institutes that carry out both teaching and research activities. They offer higher degrees - bachelor and above in various academic disciplines.
Business activities	These represent the core activities of HE institutes as described by (Zornada & Velkavrh, 2005)[1]
Types of business activity	Business activities include: (1) educational activities and administrative support for the education process; (2) research activities and administrative support for the research process; and (3) other activities.
Sub-business activity	Each business activity consists of sub-business activities. For instance, educational activities consist of portals and forums for e-learning, any Student Information System SIS, library systems, etc.; research activities involve research software, any Research Information System RIS, etc.; other activities include human resources, finance, marketing, publishing, etc.

5.5.3. The Framework

The assessment framework is a qualitative instrument that can be described as sequential actions conducted in five steps. Basically, the instrument starts with a general

[1] More details on these processes are found in Section 5.5.4.

evaluation and then proceeds to a more detailed analysis. These steps provide a logical sequence to follow.

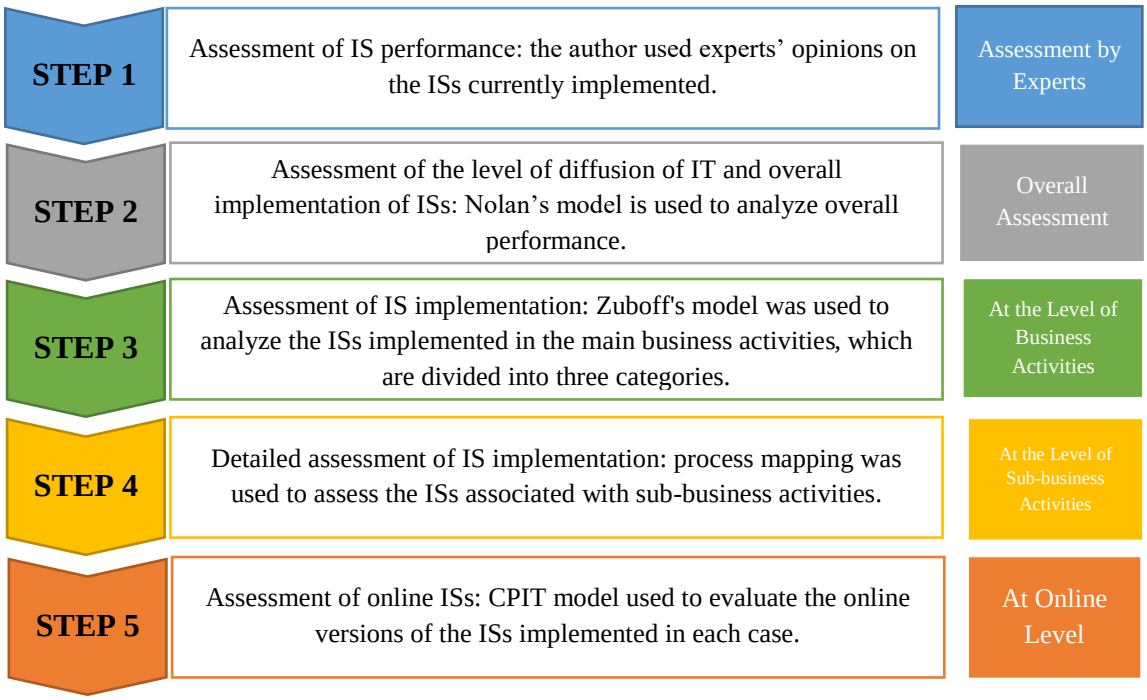


Figure 11: The Framework for assessing the implementation of ISs

As illustrated in Figure 11, in Step 1 the author evaluated and described the performance of ISs based on experts' opinions using the assessment criteria presented in Table 10. The experts are the participants of the fieldwork in Libya. In Step 2, the overall performance of IS implementation was analyzed using Nolan's model, which is a well-known model for assessing the level of diffusion of IT in an organization. Nolan's model was used to assess at which stage each case finds itself in the overall implementation of ISs. In Step 3, the ISs associated with the three main business activities (educational activities, research activities and other activities) were discussed and compared to each other using Zuboff's model. In Step 4, the author discussed the sub-business activities and associated ISs in more detail. These details contain information on the status of the system associated with each sub-business activity. In Step 5, the author discussed and evaluated e-solutions (online systems) using the CPIT model. Unlike in the original framework developed by (Akeel, et al., 2013), the author treated the online and offline systems separately, using the CPIT model to assess the online version.

5.5.4. Organizations Targeted for Assessment

As mentioned in the methodology chapter, the collaborative approach is intended to enable participation by LHE institutions of any form (such as universities, community colleges, research centers, etc.) that wish to join the consortium. It is not practical to

include all types of HE institutions in the case studies. Hence, Libyan public universities were used as a model in studying the possibility of applying such an approach in LHE (since they carry out the full range of activities carried out in HE). A categorization of higher education institutions in Libya is presented in Chapter Six: Libyan Case Studies and Findings.

5.5.5. Models and Techniques Used in the Framework

Over the past decade, several techniques and models have been developed in the field of ISs to investigate issues in an organization related to information technology. The techniques and models used in this research were applied taking into account that the technological and organizational levels in a developing country such as Libya differ from those countries in which these models were originally developed and tested. The models and techniques used are as follows.

1) Model of Business Activities in HE

To study both business and associated sub-business activities[1], the author adopted the model of business activities in HE institutes presented by (Zornada & Velkavrh, 2005). This model was shown to the interviewees to confirm with them whether or not these business processes and sub-business processes occurred in their organizations and whether some had been omitted. As shown in Figure 12, the business activities in HE institutes can be divided into:

- The implementation of educational activities and administrative support for the education process.
- The implementation of research activities and administrative support for the research process.
- Other activities (human resources, finance, marketing, publishing).

[1] The term "business activities" is normally synonymous with "commercial activities", i.e. any activity with the primary purpose of making a profit. In this research, however, it represents the core activities of HE institutes.

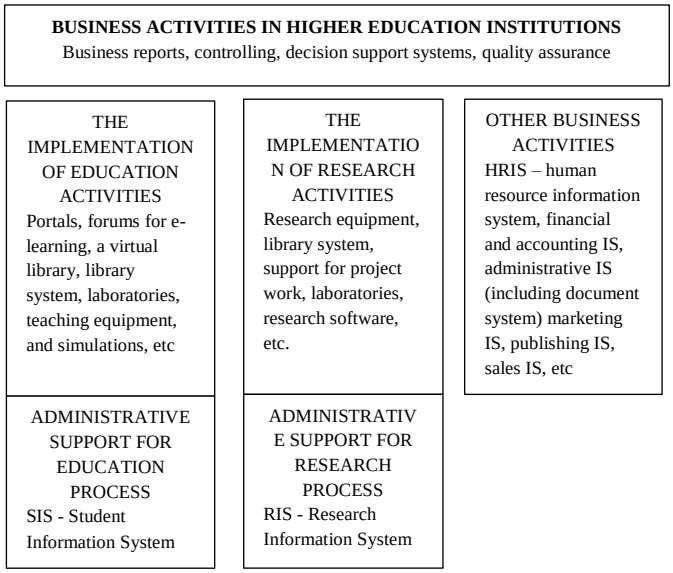


Figure 12: Business activities in HE institution - Source: **(Zornada & Velkavrh, 2005)**

2) Stages of Growth Theory (Nolan's model)

Stages of Growth Theory (or Nolan's model) is another theory used in this research from classical studies of the IS field. As mentioned above, classical studies can explain to us the sources of the knowledge that we have today and where it will go. Richard L. Nolan developed such a model for IT systems in 1973. At that time, the microcomputer had not yet been invented. Within this context, however, Nolan provided a vision for what might occur if an organization reduced the costs of data processing. Visionary in his approach, many of his forecasts came true (Hollyhead & Robson, 2012). This theory provides an understanding of the way in which IT evolves. Without going into technical details, senior management and IT management have the opportunity of directing this complex phenomenon. The first version of this theory was published in 1973. This theory has been used by various large concerns across the globe (Nolan & Koot, 1979).

Basically, this theory explains that the process of IT in an organization may be divided into several stages. Each stage has its specific problems in the areas concerning the information system, users, technology, IT personnel and management instruments (Nolan & Koot, 1979). In the 1980s, Nolan's theory was probably the most well-known and widespread framework to describe the growth and development of IT in organizations (Davis, et al., 1989). According to Lee & Lee, Nolan's model is the most widely cited model for describing and managing the growth of information systems. Because of the model's simplicity in explaining growth patterns, it soon gained popularity with practitioners and researchers and became a widely cited model of the evolution of computer systems in organizations (Lee & Lee, 1991).

Although this model has been modified over time, it is still used to discuss the growth of IT in an organization and is used by many companies and consultants to categorize the evolution of what are known, in this context, as data processing departments. Nolan's

theory can provide a useful framework for carrying out an audit, especially by a less-experienced auditor, who may not have had extensive exposure to a wide range of IT systems (Hollyhead & Robson, 2012). Basically, Nolan discovered that the pattern of growth of the budget for IT shows what he called a crude S-shaped behavior. This discovery was based on an extensive case study of three companies, In his work, he proposed that the curve describing the IT budget would serve as a useful surrogate for representing the phenomenon of the increasing use of computers in organizations and that tasks such as planning, organizing, and control were closely aligned with the growth of the IT budget. Along the growth path of IT use, most of the tasks in the management of IT can, consequently, be classified into stages. Based on these arguments, he proposed a four-stage model. In 1974, Nolan and Gibson claimed that the S-shaped curve is driven mainly by changes in IT. They declared that, in particular, database management systems would be the driving power for the shift to the next stage. Nolan revised his earlier model in 1979 when the original four stages were expanded to add two stages to make it a six-stage model, as illustrated in Figure 13.

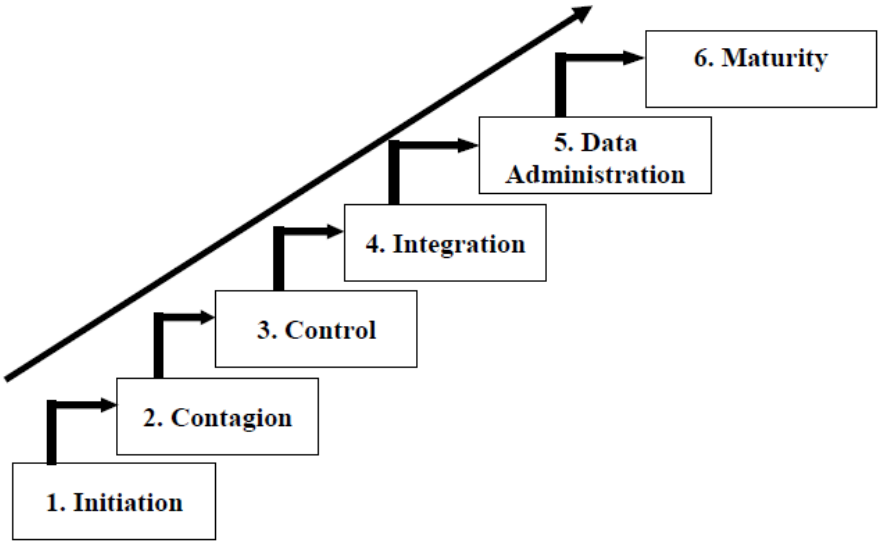


Figure 13: Nolan's model of the evolution of the IT/IS function - Nolan 1979 - Source: Strategic Information Management, 2009

Stage 1 - Initiation

The organization becomes acquainted with automation in the initiation stage. To reduce costs, efforts are made to automate labor-intensive operations. In this initial stage, users cannot and do not want to have any involvement in automation (Nolan & Koot, 1979). As identified by Nolan, this stage is concerned with the introduction of new technology into an organization. It is the point at which an organization first purchases technology. At the present time, this initial stage is becoming harder to determine. Indeed, there were no minicomputers in the 1970s, but currently, the prices of laptops are tumbling and the use of smartphones for many day-to-day business functions makes it considerably tougher to determine this start point. Personal devices, such as smartphones, are regularly

being repurposed for the needs of business. In this way, this stage is becoming blurry. Our growing dependence upon IT also continues unnoticed. A base level of IT infrastructure is now certain to be found within all larger organizations (Hollyhead & Robson, 2012).

Stage 2- Contagion

As the organization becomes more familiar with the possibility of automation, there is an increase in the need for other sorts of systems (technologies). This is, however, a critical stage of IT growth and relies heavily on the system administrators inside the organization. Undeniably, various technologies may compete to become dominant within the organization, e.g., should the system be internal to the organization or are cloud technologies appropriate? Alongside the growth of IT, the organization is also expanding. An internal IS auditor can assist the organization's progress through this chaotic stage and into the next stage (Hollyhead & Robson, 2012). The budget also grows considerably in this stage as the system expands. Also, the decisions as to which systems ought to be built and in what order are also mainly in the hands of the internal IS auditor (Nolan & Koot, 1979). At the end of the contagion stage, links should start to be formed between various information systems. These links, however, are between systems in the same department, such as automated data transfer between online/offline student systems. Links between information systems in different departments start to form in the fourth stage. By the end of the second stage, organizations have considerably expanded their information systems (Nolan & Koot, 1979).

Stage 3 – Control

Due to the spread of automation systems throughout the organization and the failures encountered in stage 2, there is a need to introduce controls. Systems may be replicated in various departments, which leads to budget concerns, as replicated systems consume more resources. An internal audit can determine the need for such control, even when the early stages are successful (Hollyhead & Robson, 2012). According to Nolan, the development of a system is usually split into two steps in this stage. In the first step, due to the lack of any control instruments and the intense pressure to implement new systems, the writing of supporting documentation is underdeveloped. This has negative effects on the maintenance of the systems. Consequently, after a while, the systems also start to be neglected. During the second step, management no longer allows systems to be neglected and system maintenance becomes a crucial topic. In this step, the user's role also becomes increasingly important (Nolan & Koot, 1979).

Stage 4 – Integration

After getting systems under control in the previous stage, the information supply is grafted into virtually separate systems and forms of technology. There are some links between functional groups, but these links are complex. Such chaos leads to threats. Integration between systems is undertaken in this stage to clean up this chaos. To take the right approach to integrate systems across departments and organizational divisions, the

majority of information systems have to be reconstructed (Nolan & Koot, 1979). The organization may wish to further develop the IT systems that are in use and begin to consolidate these systems and the databases that underlie the core functionality of the organization. The internal IS auditor will, in this way, play an advisory role rather than a monitoring and control one (Hollyhead & Robson, 2012). Nowadays, integration usually leads to organizations considering ERP systems. The market for these has grown rapidly in the last 20 years, and many vendors offer services to small and medium-sized enterprises (SMEs). It is feasible, therefore, that an organization that experiences brisk growth may be able to jump from stage 1 to stage 4 without the growth/plethora of systems associated with stages 2 and 3, and with lower costs, which is particularly needed in environments such as universities.

Stage 5 – Data Administration

By concentrating more on systems development, IT shifts from internally-oriented to externally-oriented activity. It becomes necessary to process data from several places (distributed systems). In the fifth stage, vital attention is paid to this architecture, to achieve external automation and, via this, distributed systems (Nolan & Koot, 1979). The data administration stage is less of a technological shift and more of a philosophical change of culture within the organization. The issue of data ownership (DO) is at the forefront at this stage. In this stage, rather than the data being owned by the IT department (or outsourced provider), the internal IS auditor has to "ensure that data and information resources are being used effectively and correctly by an organization" (Hollyhead & Robson, 2012).

Stage 6 – Maturity

The final stage identified by Nolan is reached when all of the systems within an organization are developed to a fine degree and can be said to have reached both a technological maturity and system stability commensurate with the business's reliance upon these systems. It is also possible for the organization to become complacent, in which case strategic drift could ensue. However, in reality, the pace of technological and business change means that systems need to be constantly developed (Hollyhead & Robson, 2012). As the IT era progresses, there is increasing pressure from the organization to organize IT at the level of a division or business unit (Nolan & Koot, 1979).

After stating the findings of this research regarding the current level of IS adoption in the three Libyan universities considered in the case studies, the author will illustrate the results using a figure based on Nolan's Model. This figure will show the current state and direction of change with growth rates in each case. Hence, a comparison is made between these case studies according to the state of their systems.

3) Zuboff's Model

The concept of (automate, informate, and transformate) was introduced by Zuboff to describe the impact of information technologies on organizations: (Angeles, 2013)

- "Automate" refers to the use of Information Technology (IT) to replace the use of human resources in undertaking business processes, tasks, or work activities, to gain operational efficiencies (e.g. IS applications for Human Resource Management (HRIS), either an in-house application or ERP).
- "Informate" refers to the use of IT to generate timely and relevant data that can be used by workers in an organization and their external trading partners (e.g.: in HRIS, computer-generated reports on staff activities, absence, and other information should be analyzed based on the "Informate" term).
- "Transformate" refers to the use of IT to help organizations restructure or reconstitute their business models, processes, practices, assets, capabilities, and relationships, to create new products, services, or business processes, and reposition themselves in the marketplace (e.g. analysis of the performance of staff should be available).

In 1988, Zuboff was the first to introduce the term "the duality of information technology", as expressed in her book "*The Smart Machine*". In her work, IT was mainly characterized by two essential aspects. Firstly, technology can be applied to the automation of operations. The purpose of automating operations is to replace the effort and skill of people with the appropriate technology. This technology enables the same processes to be performed at a lower cost and with more control in a continuous manner (Zuboff, 1989) (Angeles, 2013). Secondly, technology in the IS field is meant to create information. Even when a certain application is designed to automate, it simultaneously generates information about its fundamental processes. These processes are vital for organizations to accomplish their work. The term that Zuboff introduced to describe this process is "informate". This term captures an aspect of technology that may include, but also go beyond automation. The terms 'automate' and 'informate' express, at an analytical level, the duality of information technology. These terms are related to the increased abstraction of work and the increased visibility of processes, events, and objects allowing this information to be known and shared (Zuboff, 1989).

Robey and his team stated that Zuboff's theory seeks to explain the implications of IT for organizations and workers and the choices that it demands. In contrast to much prior (and subsequent) work on this topic, which did not focus much on the unique nature of IT (Robey, et al., 2013)**,** Zuboff added that automating and 'informating' are the two primary effects and analytical concepts that the implementation of information technology brings about in organizations (Zuboff, 1989).

Zuboff also argued that IT could have a transformative effect because of its unique powers to both automate and informate. The power to automate stems from the algorithms and machinery that allow IT to perform computational tasks so quickly and accurately. The power to informate stems from the ability of IT to record data about the work being

performed, creating a new resource that organizations can use to learn and improve (Robey, et al., 2013). In her socio-technical study, Zuboff described and analyzed the effects brought about in organizations and workers by IT-infusion. She also provided insights into the altering nature and experience of work. Her study reflects current and possible future outcomes of IT-infusion, both negative and positive (Kaiserlidis & Lindvall, 2004).

Andrew (2014) has researched Zuboff's theory. His findings showed that the theory developed in Zuboff's text has been used in a fairly limited and piecemeal fashion. His research indicates how this presents a significant opportunity for research because Zuboff's theory appears to be just as relevant now as it was when the text was published in 1988 (Taylor & Murphy, 2004)**.** According to Lee (1991), an inductively developed theory (such as the theory of the *Smart Machine*) can subsequently be tested deductively by researchers with a more positivist or quantitative inclination (Lee, 1991). Zuboff's work had not been tested until Andrew researched her theory. Andrew considers that it is remarkable that such a highly cited theory had not been tested before his research was carried out (Taylor & Murphy, 2004).

This model was used to analyze the three terms of Zuboff's Model: 'automate – informate – transformate', for ISs in the three case studies on Libyan Universities. Business processes are placed on the Y-axis, while the three terms of Zuboff's Model are placed on the X-axis, as shown in **Table 11** below. Discussions will be made at various intersections of the X and Y to give further analysis on the relationship between the three terms and business processes in each university.

Table 11: Structure of Zuboff's Model used for the analysis of business processes at Libyan Universities

Business Processes	**Automate** measure technical aspects of IT (rate of information flow, accuracy, timeliness)	**Informate** IT production and project implementation	**Transformate** service perspective, intangible benefits (trust, loyalty, brand, etc)
Business Process 1			
Business Process 2			
Business Process 3			
….			
….			
Business Process N (where N is the number of business processes in the university that is being analyzed)	e.g. students' grades are stored in a database	e.g. databases can be used to produce reports for management	e.g. students can check their grades and question them online

This model is used to assess IS adoption in Libyan Universities. After discussing the information gathered regarding each business process in a university, the author presents the complete table in the Findings and Discussion chapter. Such a procedure was repeated for each case study. In this way, it was easier to compare these case studies and

to provide the reader with a broad understanding of the current level of IS adoption in each business process.

4) System Profiling and Process Mapping

Nowadays, nearly all business processes are supported by information systems. Even when a system is based on paperwork, at some point it is generally supported by a computer application, such as MS Office. Noticeably, information systems are important today in almost every business process in organizations. Organizations can be classified into manufacturing organizations and service organizations. Theoretically, the difference between these classes is often explained by utilizing the extremes on the manufacturing/service continuum. In real life, many organizations are at an intermediate point of this continuum. Service organizations, such as universities, should not forget the roots of quality management, which goes back to Taylor (1911), Juran (1988) and Deming (1982). Gaining better control over what is going on within an organization means knowing and understanding its basic business processes (Verboom, et al., 2004).

Several definitions of business processes can be found in the literature. Most authors agree that processes have internal and/or external customers and have to produce output for them. Business processes are decomposed into several more elementary steps (activities) that are executed according to certain rules. This is a common aspect of such definitions, as observed by (Giaglis et al. 1999). A process has to be described in a way that specifies which activities have to be executed, in what order and what resources are required for the execution of these activities (Stemberger, et al., 2004).

Modeling business processes is a widely-used tool to achieve a better understanding of an organization's business processes. Modeling business processes within organizations may be achievable through a diversity of methods and techniques. Several techniques and methods attempt to effectively represent various forms of modeling to visualize an organization (Stemberger, et al., 2004). The goal of visualizing an organization as a set of business processes is a description of the organization as a mechanism for transforming inputs into outputs. This mechanism consists of many sub-businesses. Each of these sub-systems carries out specific functions. Business processes are organizational sub-processes (Biazzo, 2002).

Increasingly, there is a desire for appropriate techniques and methods, to identify models and analyze business processes. The growing popularity of business process modeling has led to a rising number of modeling techniques and methods. A survey by Kettinger et al. (2001) revealed approximately 350 tools for business process modeling. At the same time, no single technique or method can capture the whole spectrum of views. The choice of a modeling technique for a particular project should be based on matching the virtues and limitations of various techniques with the objectives of the project (Stemberger, et al., 2004). One of the widely used techniques for process modeling is process mapping (Stemberger, et al., 2004). Process mapping has been applied as a tool

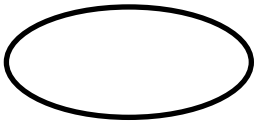
to define and analyze the processes in an organization and thereby to improve performance (Jacka & Keller, 2009) (Biazzo, 2002). As will be explained later, this method is based on flowcharts and easy to understand. It is believed that this technique can only provide basic facilities for representing processes and is inappropriate for simulation (Stemberger, et al., 2004).

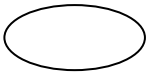
Organizations can use process maps to visualize ISs. Process mapping has been used widely for making precise illustrations of business processes in organizations. This delivers to the management of the organization the opportunity to maximize the efficiency and effectiveness of its processes. Simultaneously, the mapping will provide useful insight into how efficiency and effectiveness can be further improved, since it clarifies the use of information systems within organizations (Verboom, et al., 2004). Basically, process maps are based on flowcharts, one of the oldest graphical modeling techniques. Nowadays, flowcharts are very useful as a simple, graphical means of communication, intended to provide easily understandable descriptions of processes (Stemberger, et al., 2004). Also**,** process mapping is characterized by a specific conceptualization of sub-systems and based on the notion of ``technology'' (Biazzo, 2002). Technology is typically defined in terms of:

- physical objects or artifacts
- activities or processes (the methods of production)
- knowledge to develop and apply equipment, tools, and methods, to produce a particular output.

In this research, process mapping was used to illustrate the implementation and deployment of ISs, as well as their associated sub-processes and business activities, by the subjects of the case studies. Such modeling should help in resolving research questions regarding the implementation of ISs in the Libyan context. As shown in Table **12**, the following symbols were used to construct process mapping diagrams. Firstly, the main business process map for each case study was illustrated. Later, business relationships were illustrated. Based on both of these diagrams, an IS portfolio map can be constructed. An IS portfolio map should highlight how a system functions, including both the applications and database technologies used. The communication technology (if any) linking an IS to the status of the system should be shown as well.

Table 12: The symbols used in constructing business process maps - Source: **(Olayinka, et al., 2016)**

Symbols	Description
	To illustrate the main business process

	To illustrate a sub-business process within the main business process
N.	To describe the kind of IS implemented in a sub-business process. The corresponding Roman numeral (N) describes the state of the IS as follows: I. The system is functional and effective. II. The system is functional, but needs to be enhanced. III. The system is functional, but replacement should be considered. IV. The system is functional, but needs to be replaced. V. The system is no longer functional. VI. No computerized system at all.

5) CPIT model

The term e-business has several definitions ranging from Carter's definition as "conduct of any type of business via the internet" to Chaffey's broader concept embracing "all electronically mediated information exchanges". The term e-business, however, was firstly used by IBM in 1997 to mean "the transformation of key business processes through the use of internet technologies". E-business systems, such as e-learning systems and online student portals, are crucial in any educational organization. The convergence of technologies used in both the Internet itself and web-based communications with those used for in-house systems and software package development reflects the definition of comprehensive as noted by researchers. Currently, many software packages are accessible via the Internet or the intranet. Such applications are known as "web-enabled". As a result, it is possible to say that the analysis of e-business is very similar to the analysis of information systems. To determine the degree to which e-business is adopted by an organization at the level of individual processes, the Connect, Publish, Interact, Transform (CPIT) model was developed by the UK Department of Trade and Industry. As illustrated in Figure 14, it is a model based on a 2-dimensional matrix (DTI, 2003).

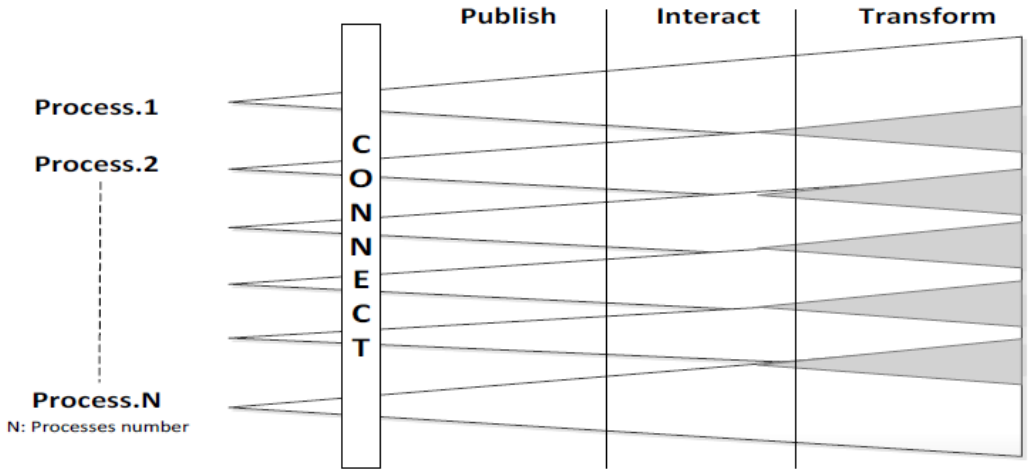


Figure 14: Structure of the CPIT Model - Source: (DTI, 2003)

The aspects considered in this model are (DTI, 2003):

- 'Connect' refers to using basic Internet technologies, such as e-mail for messaging.
- 'Publish' refers to publishing information using online technologies, for example, a static website used solely for marketing purposes.
- 'Interact', refers to a two-way process, which occurs when an organization allows its users to interact with them online. Online student portals are an example.
- 'Transform' refers to an organization using online technologies to fully transform its business processes.

The concept of analyzing the impact of e-business at the level of processes was taken a step further by DTI's model (CPIT). This model of e-business adoption identifies five simple stages in developing the capability of e-business, providing an evolutionary viewpoint on how organizations might develop their online strategies (DTI, 2003). The CPIT model is a more practical method of illustrating and interpreting patterns of e-business adoption amongst SMEs than the DTI's Adoption Ladder model. The first model better accommodates the multiplicity of ways of implementing and adopting approaches to e-business, as employed by SMEs, and enables analysis at the process level (Taylor & Murphy, 2004).

In this research, the e-business carried out by the universities considered in the case studies will be analyzed using the CPIT model. This model illustrates the integration between business processes with the use of a series of expanding arrows to replicate how business processes interact and overlap. Firstly, the author analyzed the level of development of e-business separately in each business process. This resulted in a table such as the one shown in Table 13, where each business process is placed in the appropriate column. The CPIT model of e-business should define two elements:

- The Connect, Publish, Interact and Transform (CPIT) axis, which classifies how e-business technologies are used.
- The business processes or activities that e-business technologies can be applied to.

Table 13: Template for analyzing the adoption of e-business

e.g: using basic Internet technologies, such as e-mail for messaging.	e.g: a static website used solely for marketing purposes.	e.g: the interaction between the users and the online system	e.g: the organization has fully transformed its business to online content.
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

5.6. Summary

In this chapter, the author has discussed the definition of the variables involved in the study, as well as presenting the hypotheses and the way in which they will be tested. The assessment framework used in the study was also discussed. The assessment framework used as an instrument to evaluate the implementation of ISs was also described. The terms used in this framework were also explained. The models and techniques used to conduct

the assessment were introduced as well. However, it was intended that international examples of projects using a similar approach would be studied using online questionnaires based on the SERVQUAL model. Unfortunately, no representative of any of the organizations contacted gave a reply. In the next chapter, the case studies and observations from the fieldwork in Libya are presented.

CHAPTER SIX: LIBYAN CASE STUDIES AND FINDINGS

6.1. Introduction

As mentioned earlier, the study uses multiple case studies to investigate the Libyan context. In this chapter, the background to the case studies is presented, as well as the findings from the fieldwork in Libya. Although the subjects of the case studies are independent, there are similarities in terms of the aspects of the study procedure, e.g. the methods of sampling, data collection, and analysis. These similar aspects are described in this section, while aspects unique to each case will be indicated in more detail later.

Due to the specific nature of the group of people who are working on/familiar with ISs and the ERP approach in the Libyan context (they form a "niche" population), the author chose to use convenience sampling. This is a type of non-probabilistic or non-random sampling where members of the population who are available at a given time and/or place and express willingness to participate are included in the study. Secondly, the author used a method combining aspects of both snowball and Respondent-Driven Sampling **(**RDS) in the recruitment strategy. The author asked each respondent to give an estimate of the size of his/her network. This helped to decide whether to use interviews or questionnaires. Recruiting is driven by interviewers rather than by respondents, as in snowball sampling. Thirdly, to study both business and associated sub-business activities[1], the author adopted the model of business activities in HE institutes presented by (Zornada & Velkavrh, 2005). This model was shown to the interviewees to confirm with them whether these business processes and sub-business processes appear in their organization and should other processes be included. Business activities in HE institutes can be divided into:

- The realization of educational activities and administrative support for the education process.
- The realization of research activities and administrative support for the research process.
- Other activities (human resources, finance, marketing, publishing).

6.2. Sample Size

Based on the structure of Libyan universities, there is always a division for IT-related issues whose aim is to develop and build a distinct technical environment to increase the efficiency of work and improve both academic and administrative performance within the

[1] The term "business activities" is normally synonymous with "commercial activities" including any activity engaged with the primary purpose of making a profit. However, in this research, it represents the core activities in HE institutes.

university. As IS implementation is the main interest in this study, this was the best starting point for the study, especially as these divisions contain a department dedicated to developing and maintaining the ISs deployed across the university. Consequently, the target population is composed of experts in the Centre/Department/Division for IT related issues in each case study.

Sample size assessment is used to determine the minimum number of participants needed for the study. If the sample size is too small, the chance of inconclusive results is high, while resources may be wasted if the sample size is too big. In this study, the population is niche. For this reason, a method of non-random sampling, snowball sampling/RDS, was chosen. When adopting non-random methods, generalizing the results from the sample to the whole population may be difficult. The initial study helped direct the other case studies that were carried out with greater effectiveness. Indeed, despite the risk of higher error, the purpose of the initial study was not only to obtain a precise answer, but also to gain a general idea of sample size, methods adopted and techniques used.

After conducting the initial study, the author assessed the minimum number of participants necessary in other cases to be 2. The initial study indicated that the department responsible for IS implementation is the Department of Information Systems of the IT division, which is usually called "the IT Centre" or something equivalent. Besides the department head, the number of specialists IS employees in this division might vary from one university to another, usually within the range of 4-7 people. Also, there is usually a local IT team in each faculty with a minimum of 3 working staff. However, the team in each faculty usually consists of a mediator and data-entry staff. Accordingly, the author excluded them since they do not play a role in decision making regarding the IS strategy. As in the initial study, in the other cases, the author first targeted two respondents as a minimum, namely: the head of the IT Centre, as well as the head of the IS Department or equivalent. These two initial seeds could recruit other respondents, whose position might vary from one case to another. The differences occurring in terms of the number of participants in each case study are indicated later on. The goal of these studies is to evaluate the level of IS implementation in Libyan universities.

6.3. Libya's Background

Libya is an Arab state and classified as a developing country. It is located in North Africa and currently named "The State of Libya". The state religion is Islam, with nearly 97% of Libyan citizens being Sunni Muslim. The official language of the country is Arabic, while English and Italian are fairly commonly understood. The country occupies an area of almost 1.8 million square km with a population of 6.2 million. The capital of Libya is Tripoli, which is home to approximately 20% of Libya's population, while the three other major cities of Libya are Benghazi, Sabah, and Al-Bayda. By area, Libya is the seventeenth largest country in the world and the fourth largest one in Africa. Due to its geographic features (mainly desert and many isolated areas), the educational

opportunities available to Libyan students are not uniform. The open classroom program was launched to overcome this obstacle. On the other hand, e-learning is still not recognized as a valid model of education (UNIGOV, 2016) (MOE, 2019).

6.3.1. Higher Education (HE) in Libya

After Libya gained independence in 1951, the Libyan University was established in Benghazi as the first University in Libya. The founding institution was the Faculty of Arts and Education. In 1957, the Faculty of Science was established in Tripoli. The Faculty of Economics and Commerce was established later in the same year. These faculties were followed by the Faculty of Law in 1962, the Faculty of Agriculture in 1966, the Faculty of Higher Technical Studies, the Higher Teachers Training College in 1967 and the Faculty of Medicine in 1970. In 1970, the Faculties of the Arabic Language and Islamic Studies were established by integrating the Islamic University in Al-Bayda into the Libyan University. The faculty of Oil and Mining Engineering was established in 1972, This Faculty was later moved to the Brega Oil Terminal Complex. In 1997, other higher education institutes for teacher training were founded. Recently, new scientific institutes known as Scientific Research Centers have been established. These institutions are both educational and research institutions (Tamtam, et al., 2011) (UNIGOV, 2016).

The Libyan University divided into two different universities in 1973: The University of Tripoli UOT, formally known as “AL-Fateh University” and the University of Benghazi, formally known as “Garyounis University”. Due to the increasing number of students enrolling in higher education, since 1981 many public universities have been established. Currently, there are 18 public universities, 148 specialized faculties and over 500 specialized scientific departments (TEMPUS, 2011).

As shown in Figure 15, the university system in LHE is a three-stage program: 1) Undergraduate degree (Bachelor’s degree - four to five years), 2) Master’s degree - two years of study, and 3) Doctorate - three years of further research and conditional on the submission of a thesis.

Apart from the set of universities, LHE also offers higher vocational and technical education. The latter program lasts 3-5 years. It is offered by higher education institutes in the following fields: electrical and mechanical engineering, finance, computer studies, industrial technology, social work, civil aviation, etc. (TEMPUS, 2011).

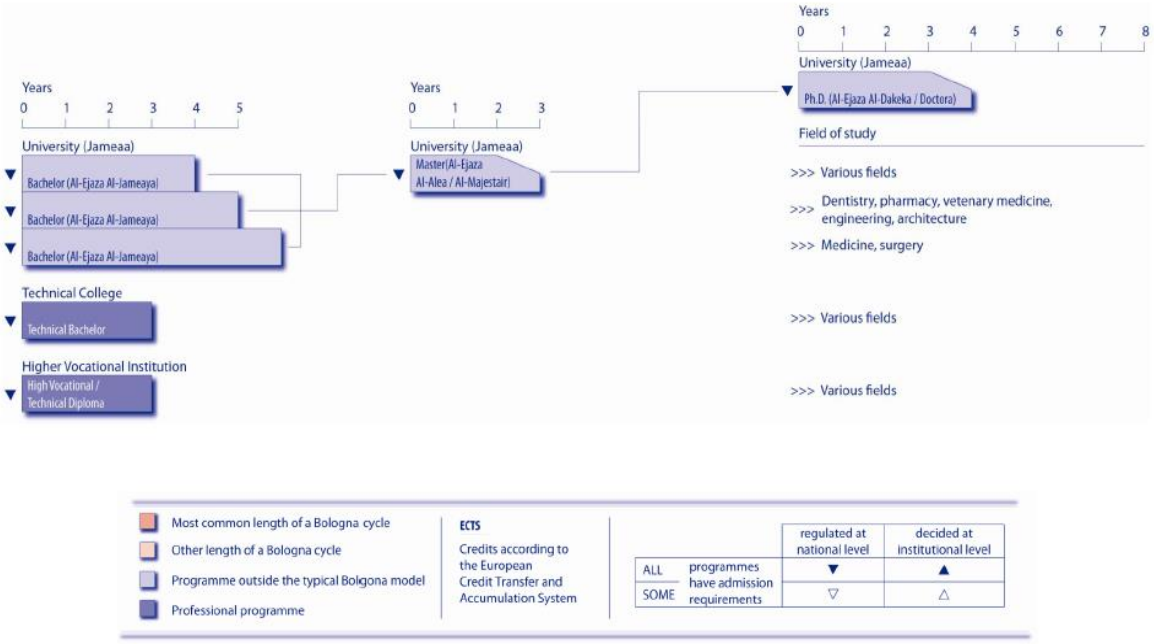


Figure 15: Description of the Libyan higher education system in general and the university system in particular – Source: **(TEMPUS, 2011)**

The education system is financed by and under the authority of the state government. The Department of Higher Education supervises all the activities and operations of all the public HE institutes in the country. The Open University is the only institution within the public sector that relies to some extent on tuition fees paid by students. In recent years, policymakers in Libya have allowed the establishment of private institutions of HE through what are known as educational co-operatives. This has led to the establishment of more than 30 private universities/community colleges providing education in all disciplines (MOE, 2019). In total, there are almost 300 thousand students[1], as shown in Table 14. Furthermore, there are 17 community colleges, as shown in Table **15**, which are under the Libyan National Commission for Technical Education (LNCTE). [2]

Table 14: Libyan Public Universities - Source: **(LME, 2019)**

No.	University	Year Founded	No. of Students
1.	University of Benghazi	1955	70523
2.	University of Tripoli	1957	74450
3.	Omar Al-Mukhtar University	1961	50105
4.	University of Mohammed bin Ali al - Sanusi	1961	4525

[1] The numbers of students are only given for public universities. As previously mentioned, the study was limited to universities.

[2] Note that private HE institutes were excluded from the study, since there is limited reliable information on these organizations.

5.	Sabha University	1976	25000
6.	Bright-Star University	1981	9680
7.	Al-Arab Medical University	1984	6300
8.	Misurata University	1984	16358
9.	Gharyan University	1985	10230
10.	Open University of Libya	1987	2921
11.	Academy of Graduate Studies (all branches)	1988	8520
12.	Al Zawiya University	1988	8700
13.	ElMergib University	1991	11350
14.	Tobruk University	1991	5201
15.	Sirte University	1992	14857
16.	Alsmariya University	1996	4223
17.	Azzaytuna University	2001	4980
18.	Sabratha University	2015	4400
19.	Bani Waleed University	2015	5255
20.	Alzentan University	2017	3300
21.	University of Fezzan	2017	2980
22.	Nalut University	2017	2828
23.	University of Jafara	2017	3100

Table 15: Community colleges in Libya - Source: **(LNCTE, 2019)**

No.	**Community Colleges**
1.	College of Computer Technology – Tripoli
2.	College of Electronic Technology - Bani Walid
3.	College of Electrical and Electronic Technology – Benghazi
4.	College of Administrative Sciences and Applied Finance – Tripoli
5.	College of Industrial Technology – Misurata
6.	College of Computer Technology – Zawiya
7.	College of Engineering Technology – Zuwarah
8.	College of Electronic Technology – Tripoli
9.	The Islamic Call College – Tripoli
10.	College of Engineering Technology – Hun[1]
11.	College of Engineering Technology – Janzur
12.	College of Medical Technology – Derna
13.	College of Medical Technology – Misurata
14.	College of Mechanical Engineering Technology – Benghazi
15.	College of Tourism and Hospitality – Tripoli
16.	Technical College Of Civil Aviation & Meteorology – Esbea
17.	College of Structural Engineering – Msallata

[1] The town of Hun is the capital of the Al-Jufra District.

6.3.2. Information and Communications Technology in LHE

In recent years, researchers have observed that no improvements in HE can be achieved without engaging ICT. Applications for education management and administration can facilitate and improve the level of teaching and learning. HE institutions and the government should develop an effective strategy for implementing modern technology in the educational system, to maintain the country's competitive advantage and to keep up with international standards. In fact, the greatest challenges faced by Libya are the need to improve and develop its technological infrastructure and a lack of skilled and qualified teachers (TEMPUS, 2011).

In Libya, access to ICT tools is still lagging behind in many fields, such as government services and commerce. Libya, as a developing country, is eager to adopt new information technologies. The government was pushing toward implementing technologies in education before the uprising in 2011. Indeed, several initiatives and projects were active in Libya. In 2005, the national policy for ICT in education was launched. The Ministry of Education and the Ministry of Vocational Training (currently the Ministry of the Higher Commission for Vocational Training) play the greatest roles in developing the national policy for ICT with the support of other parties, such as the General Postal and Telecommunications Company and Libya Telecom and Technology LTT. The policy aims to enable access to ICT through the provision of computers and the Internet. It was intended that these plans would be fulfilled in the short term and there were some signs that the policy was being followed up and implemented (MOE, 2019) (Hamdy, 2007).

The Libyan Higher Education and Research Network (LHERN) was also the subject of a major project, supported and sponsored by UNESCO and the government of Libya. These projects proposed the development of Local-area Networks (LANs) in almost 150 faculties in different universities and a Wide-area Network (WAN) to integrate numerous institutions providing HE. This project also anticipates the establishment of a national ICT resource center and the automation of universities' management systems (Hamdy, 2007). Also, Libya launched an electronic database for the results of secondary education examinations in 2008. Furthermore, some pilot projects to apply e-learning in primary schools have also been implemented. The Ireland-based River-deep has developed a successful e-Learning pilot project covering six schools in Tripoli, where the Mediterranean Coast for Information Technology [MCIT] company designed and provided the entire system. Also, distance education is provided by Libyan Open Universities (LOUs), which offer the opportunity to study at home. UOT has also launched an e-learning system, which will be discussed later (MOE, 2019) (TEMPUS, 2011) (Hamdy, 2007).

All of these projects were either paused or are barely functioning after the uprising in 2011. However, the new Libyan government is now working hard to provide technological infrastructure to all universities as soon as possible. The United Nations Development

Program [UNDP] and the United Nations Educational, Scientific and Cultural Organization [UNESCO] provides Libya with a significant opportunity to reconstruct its education system after the recent uprising. They are working together with the Libyan Ministry of Education to ensure appropriate and timely implementation of their strategies on information and communication technology (Alghali, et al., 2014).

6.4. Case Study 1: The Initial Study on University of Tripoli

In this research, the initial study was the second phase of this research's master plan, following the literature study and preceding the formal study. In fact, the initial study was the first step in the fieldwork in Libya. As stated previously, data gathering in this study is based on three main resources: 1) international experiences of implementing a similar approach; 2) a review of the relevant literature and 3) the national context for which this approach is being proposed, Libya. As this context is considered to be the most crucial part of data gathering, data collection was piloted in the initial study, prior to the interviews conducted in the formal study. The importance of piloting data collection is recorded in the literature. Saunders et al. stated that the validity and reliability of data depend on the design and structure of questions, and the strictness of the pilot study (Saunders, et al., 2015). In this section, the initial study is described, together with its significance and objectives. Also, the observations from the initial study are discussed and analyzed on the basis of chosen models.[1] Due to the structure followed in this thesis, an analysis and discussion of the observations from the initial study will be presented in the following chapter.

6.4.1. Why an Initial Study should be Conducted

After the research topic and questions have been set, an initial study is conducted either as a mini-version of a full-scale study or as a trial run of the complete study. In the social science literature, this is known as a 'feasibility' study. Such pilot studies are used to pretest particular research instruments, methods, techniques, questionnaires and interviews. In other words, initial studies are usually executed as planned for the intended study, but on a smaller scale. Such studies are also known as "Dress Rehearsal Studies" or "Exploratory Studies" (Blaxter, et al., 2006) (Baker, 1994).

Firstly, why should an initial study be conducted? Several reasons are given in the literature regarding the advantages of conducting an initial study, including: it can indicate the weaknesses in a proposed study and where the main research project can fail; to check whether the proposed methods/instruments/techniques are appropriate and not too

[1] The initial work in this study is published in the Proceedings of the 11th International Conference on Knowledge Management and Information Systems held in Vienna, Austria, 17-19 September 2019--Volume 3: KMIS, ISBN 978-989-758-382-7, pages 203-211. DOI: 10.5220/0008119902030211.

complicated; to identify practical problems in the research procedure, such as instructions and time limits; to check the structure of a questionnaire or interview to avoid misleading, inappropriate, or redundant questions; to help determine the sample size in future research and to validate the reliability of results (Welman, et al., 2011) (David, 2001) (Fink & Kosecoff, 1985).

Above all, this initial study can be interpreted as a pre-testing of research techniques and methods, questionnaires and interviews. Specifically, the initial study is of value for testing the feasibility of research instruments or methods of data collection by finding practical arrangements that might have a negative influence on the success of the research procedure. Besides guiding adaptations of the survey and interviews for later case studies, the initial study may be used to determine whether or not additional case studies of Libyan universities should be included, as well as the minimum number of participants in the formal study.

6.4.2. About the Initial Case Study

The University of Tripoli (UOT) was chosen as the subject of the initial case study, since the author is a staff member of this university and it is the leading university in Libya. Also, the UOT has effectively contributed to the establishment of many universities in Libya by providing consultants and educators. These collaborations contribute to the similarities between all of the Libyan universities.

The University of Tripoli (UOT) is a public university, the largest institution of HE in Libya and the national leader in academic teaching, scientific research, and knowledge development. It was established in 1955 and opened in 1957 with the founding of the Faculty of Science. It consists of 6 campuses located on more than 300 hectares, distributed over different locations within the city of Tripoli. In UOT, there are 20 Faculties with 154 academic departments. The degrees granted by UOT are: Bachelor of Science (80 programs), Master of Science, Master of Arts (113 programs) and Doctor of Philosophy (19). The local teaching staff has 2970 members, while there are 80 international teaching staff. A total of 74450 local students and 1598 international students are registered in undergraduate programs, while 3628 local students and 93 international students are registered in graduate studies. A total of 21 libraries are located around all of the campuses. UOT runs 6 journals approved by the Libyan National Book House and 17 other journals (UOT-Website, 2019).

6.4.3. The Case Study Respondents

The pool of contacts was expanded by snowball sampling/RDS using participants' recommendations. The recruitment of participants consisted of contacting three participants from UOT, who were labeled T-1, T-2 and T-3. These respondents were all experienced in the use, support, and management of ICT within the university. The responses received from the participants provided the author with an initial understanding

of the general level of ICT in UOT. In particular, the responses assessed the level of the ISs implemented at the university and UOT's capabilities for implementing in-house applications. Brief descriptions of the respondents are given in Table 16.

Table 16: Summary of respondents participating in the UOT case study

Respondents	Position	Years of Experience
T-1	Former Head of Centre for ICT	5
T-2	Head of Centre for ICT	10
T-3	Head of Information Systems Department in the Centre for ICT	7

The author witnessed a new shift at the Centre for ICT, which allowed observing a very critical change that could affect the entire ICT process at the university. The author started the interview process with the former head of the Centre for ICT (T1) when he was still holding the position. Soon, the interview was paused, because of an unexpected battle in Tripoli during August and September 2018. Once the battle was over, a new head of the Centre of ICT had already been appointed. However, the author continued the interview with the former head of the Centre. Indeed, T1 possessed more knowledge on the ICT Centre, as well as being the initial seed of the sequence of interviews. He then proposed the new head of the ICT Centre (T2) as a potential seed. Thus, the author started another interview with the new head of the Centre, who in turn recommended the head of the Information System Department (T3). Such a proposal was natural since the target ICT component was at the level of IS implementation rather than the overall level of ICT.

According to Bryman, a questionnaire or interview can be presented to participants in one of four ways: 1) by mail, if an interview is required this can be carried out later using a different form; 2) by telephone; 3) face-to-face and 4) via the Internet, either through a website particularly designed for this purpose or e-mail (Bryman, 2001). For this study, the author was unable to travel to Libya. As a result, the respondents were first introduced to the study through e-mails, then contacted by telephone during the first session of the interview. After this, a list of the additional information needed was e-mailed to them and eventually video-conference sessions were held to conclude the interviews. The languages used in these interviews were Arabic and English for easier communication with the respondents. The lengths of these interviews were between 45 minutes and 1:45 hours.

6.4.4. Findings from UOT[1]

1) The Centre of ICT at UOT

[1] All these findings are from the interviews (T-1, 2018) (T-2, 2018) (T-3, 2018), unless indicated otherwise.

The university's ICT Centre was established to build and develop a distinct technical environment to improve the quality of work (both academic and administrative performance) within the university through the optimal use of the available resources. The ICT Centre provides networking services, access to the Internet, Intranet services, e-mail, software development, and technical support. It also provides technical consultancy and training to the University's IT staff. The ICT Centre is under the direct monitoring of the university's president. In addition to the administrative department of the Centre, it is divided into five departments with 70 employees as follows:

- Department of Networking and Information Security
- Department of Information Systems
- Department of Technical Support and Maintenance
- Department of Electronic Publishing
- Department of Documentation and Statistics

There is also an ICT office in each faculty. Each of these offices comes under the faculty's main structure while being technically supported by the main ICT Centre. In each office, there is 1) head officer who is highly knowledgeable in informatics; 2) one system administrator of all the local systems[1] who works as a contact person with the local ICT offices in each faculty and the main ICT Centre and 3) data-entry staff, in which the number of people in charge of data entry varies based on the size of the faculty and is generally between 2 and 7 people.

2) Business Activities and Associated Information Systems at UOT:

a) The implementation of educational activities

Such business activities require/consist of the following: portals and forums for e-learning, a virtual library, library system, laboratories, teaching equipment, and administrative support for the education process in the form of a student information system (SIS).

UOT lacks a unified system across all faculties to support its educational activities. To the present day, some faculties still rely on old in-house systems to accomplish some tasks, while others are still completed using paperwork. Using such a system, each faculty issues certificates and transcripts differently. The status of the SIS in UOT varies from one faculty to another. Faculties with computer departments have the privilege of being able to develop their systems, while other faculties are at a lower level of development.

In 2016, the university launched a new online system that enables students to manage their course programs. Now students in all faculties use a unified system for course

[1] The kinds of systems may vary: local "offline systems" providing students with information, online systems which are controlled by the main ICT Centre of the university or local systems used by the faculty.

registration and other similar tasks. This system operates online, while the offline version is still under development. At the same time, the exchange of information between the online system (the student portal hosted online) and the older offline systems (placed on local servers in the faculties) is operated manually using excel/SQL files.

The university's website was designed by a Tunisian company. This website was developed using an open-source package called Drupal and the php programming language that combines blogging and forum features. It is an integrated program for managing both content and members, allowing full control of the website. This Tunisian company developed only the initial parts of the website and with a great lack of data. After some attempts, this company agreed to add more features, for the ICT Centre, represented by its development team, to be able to continue developing the website. Consequently, they are developing a newer version of the website, which uses Node.js and php.

The e-learning program was launched in 2009. This program consisted of portals and forums for both the SIS and the learning system. Tasks related to students' management of their studies, such as course registration and viewing examination results, are carried out via these systems. The learning system was fully online. However, due to the uprising in 2011, the system was limited to managing studies with no ability to perform learning tasks online. Because of this, the e-learning system became similar to a traditional learning system. Hence, it was temporarily paused by the university's top management, to be relaunched in the future.

The registration of new students is electronically operated through the university's main registry. Lists are transferred into Excel or database files accessible to the faculties within the university. However, the Libyan Ministry of Education has taken power over the enrolment of new students (undergraduate programs), such that students will be registered based on their choices and results. This process is carried out through a separate system owned by the ministry. Lists of students are distributed in Excel or database files to universities and community colleges.

Other ICT issues such as laboratories and teaching equipment are not covered in detail, as they are irrelevant to the topic of this research.

b) The implementation of research activities

The implementation of research activities involves research software, support for research work, research laboratories, research equipment, as well as the Research Information System (RIS) as administrative support for the research process. In general, there is no complete IS for research business activities at the university. One of the projects launched by the ICT Centre is the Digital Archive of the University of Tripoli, DRUoT. It aims to digitally store all research, theses, dissertations, books and published papers. This system is administered by the ICT Centre and hosted within the data center inside the university. Uploading privileges are granted only to the staff of the ICT Centre, while browsing and downloading are open to the public.

Also, one of the projects that has been introduced to the university is Office 365, to take advantage of its benefits in ERP systems, e-management, and access to international journals based on a subscription. According to the Microsoft website, "Office 365" is a term indicating subscribed access to Office applications and other services. These services are enabled online as a cloud service available for home or business. Office 365 offers service subscriptions for e-mail and social networking services to businesses through hosted versions of Exchange Server, Skype for Business Server, SharePoint and Office Online, and/or integration with Yammer. All Office 365 plans are paid for by subscription, monthly or annually.

Moreover, refereed journals and periodicals issued by some faculties of the UOT, including various sciences, have implemented e-solutions. These are summarized in Table 17.

Table 17: E-solutions for refereed journals and periodicals issued by UOT

Journal	Issued by	Online System
Open Veterinary Journal (OVJ)	Faculty of Veterinary Medicine	https://www.openveterinaryjournal.com/
Libyan Journal of Agricultural Sciences (LJAS)	Faculty of Agriculture	http://www.ljagric.com/index.php/ar/
Journal of Engineering Research (JER)	Faculty of Engineering	http://www.jer.edu.ly/
Journal of Economics and Political Science (JEPS)	Faculty of Economics and Political Science	http://www.geps.uot.edu.ly/jeps/
Libyan Journal of Science (LJS)	Faculty of Science	http://libyanjournal.atspace.co.uk/
Journal of Physical Education and Sports Science (JPESS)	Faculty of Physical Education and Sports Science	http://www.alzeetona.com/aol/index.php/jssr/index/
Journal of Research and Economic Studies	Centre of Research and Economic Studies	http://www.geps.uot.edu.ly/jres/

Other business activities involve human resource information systems (HRISs), finance and accounting ISs and administrative ISs. UOT does not possess any HRIS, except for the administration of academic staff. This is another IS developed by the staff within the ICT Centre. It aims to handle the data and procedures related to academic staff. Also, there is an IS for students who are awarded a scholarship to study aboard. This system is not owned by the university, but by the Ministry itself. Other work related to human resources is done either using MS-office (Excel or Access) or by hand.

Finance and accounting are partially computerized. In the faculties, such matters are usually handled by hand or using MS-office, while the main office of finance and accounting uses an in-house application. The monthly grand program was launched in 2012. This is one of the greatest obstacles within the university, as it is connected to financial affairs and costs a large proportion of the budget. This work is done manually with the use of computer applications, such as MS Excel in most faculties, and lists are converted into the Excel format for the university’s administration section.

The administrative IS, incorporating a document handling system, is computerized in the university's central offices, such as the President of the University's office, while it is handled manually or using MS-office in other divisions. Moreover, there is a so-called "network resource management system". This is a centralized system controlling Internet access across the university campuses, in terms of ensuring the anonymity of users and determining the privileges granted, such as limits on time spent online and the amount of data that can be downloaded.

3) Hosting and Data Centre

All of the online systems operate within the university's website, including: the new registration system; the billing system which is responsible for opening and managing student, faculty and staff accounts using Office 365, as well as issuing a password for access to the University's WI-FI hotspot; a registration system for new students; and the academic staff administration system. These systems communicate with the university's website electronically. All online systems are hosted by a Libyan company on a server dedicated to the university. This option allows a developer to reserve a server with full resources and provides absolute control over the server, as it can be remotely controlled using administrator privileges. It is thus possible to install and set up any software desired. The server is located in the company, but the current CIO of the Centre is currently negotiating to move it to the university's data center. In fact, all university data is stored at the data center located in the post office building at the university. The off-line systems are not central projects of the university, but are under the management of the faculties to perform specific services. Thus, the offline systems are hosted locally inside faculty buildings.

Finally, summaries of the ISs and e-solutions implemented in UOT are presented in Table 18 and Table 19, respectively, along with their purpose and present state.

Table 18: Summary of the information systems implemented at UOT

No.	Information System	Purpose	State of the System
1.	Student Information System (SIS)	It is an information management system for educational activities, handling data on students and the needs of students	• The university lacks a unified system supporting all of its educational activities. • Each faculty runs an old legacy in-house system, using a variety of technologies. • The status of the SIS in UOT varies from one faculty to another.
2.	e-learning system (offline version)	It allows students to complete a course, solve exercises or even study without having to be physically present in the	Partially computerized using MS Excel and MS Access

		lecture hall. It also complements the traditional teaching process by building blended learning.	
3.	Enrolment of new undergraduate students (offline version)	It is designed to register new students and manage their needs	Partially computerized using MS Excel and MS Access
4.	Monthly grand system	Managing monthly grand program for undergraduate students	Manual
5.	Library system	Management Information System for Library	Some faculty libraries run purchased software packages, while others use MS Excel and MS Access
6.	Laboratories	A special system designed for laboratories.	Each faculty uses purchased software packages
7.	Virtual libraries and simulation systems	Advanced technology meant to improve teaching and students' learning experience	None
8.	Research Information System (RIS)	A database or other information system to store and manage data about research conducted at an institution	No complete software package for RIS, but rather separate software packages as indicated in (9) & (10)
9.	Digital Archive (offline version)	Uploading and managing all material regarding research, theses and dissertations, books and published papers.	Purchased open-source software package, accessible on the university's website: based on PHP and MySQL
10.	e-solutions for refereed journals and periodicals (publishing IS)	Uploading and managing journals and periodicals issued by the university	• Purchased open-source software package accessible via the university's website: based on PHP and MySQL • In-house: ASP and SQL server
11.	Human resources	Handling information needed for the management of human resources within the university	Partially computerized using MS Excel and MS Access
12.	Finance and accounting	Dealing with financial affairs	Partially computerized using MS Excel and MS Access
13.	Network resource management	Control of Internet access across the university campuses	In-house: ASP and SQL server
14.	Document Management	Tracking, managing and storing documents, letters, and official correspondence	Partially computerized
15.	Sales IS	IS adapted to sell services and products, such as books published by the university	None
16.	Decision Support System	Supporting business or organizational decision-making activities.	None

Table 19: Summary of sub-business processes and the relevant e-solutions

No.	Sub-business process	E-solution	Status of the System
1.	Student Online Registration System	Yes	All faculties use the same system which was developed by the ICT Centre's IT team using PHP and MySQL
2.	e-learning system	Yes	In-house application using PHP and MySQL

3.	Enrolment of new students (undergraduate)	Yes	In-house application using PHP and MySQL
4.	Monthly grand system	No	None
5.	Digital Archive	Yes	Purchased open-source software package as part of the university's website: PHP and MySQL
6.	e-solutions for refereed journals and periodicals	Yes	See Table 17
7.	Human resources	No	None
8.	Finance and accounting	No	None
9.	Network resource management	Yes	In-house: ASP and SQL server
10.	Document Management	No	None
11.	Sales	No	None
12.	Library system	No	None
13.	Laboratories	No	None
14.	Virtual libraries and simulation systems	No	None

6.5. Case Study II - Misurata University

6.5.1. About the Case Study

Misurata University (abbreviated to MU) is a Libyan public university, located in the city of Misurata. MU is ranked as one of the top three universities in Libya (MU, 2019). MU was founded in 1984 as an independent university with the establishment of the Faculty of Sciences. Currently, there are 15 faculties, namely: Faculty of Sciences, Faculty of Arts, Faculty of Economics and Political Sciences, Faculty of Law, Faculty of Medicine, Faculty of Engineering, Faculty of Pharmacology, Faculty of Education, Faculty of Information Technology, Faculty of Nursing, Faculty of Islamic Studies, Faculty of Languages, Faculty of Veterinary Medicine, Faculty of Physical Education and Faculty of Dentistry. Also, there are six centers, namely: Centre of Media, Information and Documentation Centre (IDC), Quality and Performance Centre, Consultancy and Research Centre, and Research and Scientific Studies Centre (Bakeer & Wynn, 2014) (MU, 2019).

In numbers, the local teaching staff has 1216 members of whom 86% are national Libyans, over 823 teaching assistants, and 550 visiting lecturers. Based on recent statistics, there are more than 16358 registered students, while 19000 students have graduated from various faculties of MU since the first graduation class of 1987. Also, MU runs 12 journals, 10 of which are approved by the Libyan National Book House. The degrees granted by MU are: Bachelor of Science (more than 100 areas of study) and 16 Master degrees (MU, 2019) (M-1, 2019).

6.5.2. The Case Study Respondents

The pool of contacts was expanded using snowball sampling/RDS based on participants' recommendations. In the interviews, the recruitment of participants consisted

of contacting two respondents from MU who were labeled M-1 and M-2. The details of respondents are given in Table 20. The author carried out the interview process with the respondents during the period May – July 2019. Specifically, the respondents were first introduced to the study through e-mails by the end of May. Then, they were contacted by telephone during the first session of the interviews. After this, a list of the additional information needed was e-mailed to them. Eventually, oral sessions were held to conclude the interviews in Libya during 1th-15th July 2019. The languages used in the interviews were Arabic and English for easier communication with the respondents. The length of these interviews was between 45 minutes and 2 hours. M-1 was the initial seed of the sequence of interviews. He proposed the head of the Programming and Information System Unit (M-2).

Table 20: Summary of respondents participating in the MU case study

Respondents	Position	Years of Experience
M-1	Head of Information and Documentation Centre (IDC)	5
M-2	Head of Programming and Information Systems Unit in the IDC	6

6.5.3. Findings from MU[1]

1) The Information and Documentation Centre at MU

The IDC is responsible for following up technical issues in the faculties and university offices, such as the programming and design of ISs and web-sites, as well as the maintenance of devices and networks located in the faculties and the university in general. In addition to the administrative unit of the Centre, it is divided into five units with 14 employees as follows:

- Unit of Programming and Information Systems.
- Unit of Networking and Information Security.
- Unit of Geographical Information System.
- Unit of Statistics and E-Publishing
- Unit of Maintenance and Technical Support.

There is also an employee in each faculty who is responsible for informatics issues and works as a mediator between the IDC and the faculty. This is similar to the structure at UOT, except that there is a whole unit available in each faculty at UOT. Besides this, there is a number of staff in each faculty responsible for data entry and this number varies based on the size of the faculty and is generally between 1 and 4 people.

[1] All these findings are from the interviews (M-1, 2019) (M-2, 2019), unless indicated otherwise.

2) Business Activities and Associated Information Systems at MU

a) The implementation of educational activities

Such business activities require/consist of the following: portals and forums for e-learning, a virtual library, library system, laboratories, teaching equipment, and administrative support for the process of education in the form of a student information system (SIS). MU lacks a unified system across all faculties to support its educational activities.

For SIS, each faculty runs its own version of the system. In fact, there are two kinds of SIS run in MU. One was developed by an external party, while the other system was developed by the MU's IT team. Both of these systems were developed using Visual Basic and Delphi with a SQL database that runs on an MS Windows platform. Some of the faculties rely on the former system, other faculties run the latter system, while a small number of faculties still use paperwork. Three main functions are performed within these systems, namely: registration of students, study and examination records, and data regarding graduate students. There are no ISs for e-learning at MU. In fact, decision-makers in MU should carefully consider e-learning as a means of gaining knowledge, as it has been used very effectively in the HE environment for enhancing traditional forms of teaching and administration. Indeed, e-learning bridges the gap between a teacher and a student who are geographically separated. Furthermore, there is another system called the System of Training Centers, which operates in the Language Center. This system is concerned with the management of training centers, such as opening and adding courses and registering students in courses. For libraries, each faculty runs its own copy of a Library Management System that is PHP-based. Again, these copies of the system are isolated. Currently, the MU-IDC is working on installing a purchased package to integrate the library system.

None of the systems mentioned above are available online. However, there is an integrated online registration system that enables students in all the faculties to manage their course programs, e.g. for course registration. Also, the exchange of information between the online system (the student portal hosted online) and the older offline systems (placed on local servers in the faculties) is operated manually using Excel/SQL files. The university's website is available in both Arabic and English. In fact, the old website was developed using templates (WordPress + PHP), while the newer version was programmed from scratch in the PHP language by the programming team located in the MU-IDC. The university website is rather primitive and does not contain accurate data. There is no integration with other internal systems and data are transferred manually from/to the website. Also, a number of websites have been designed for some faculties (Faculty of Engineering, Faculty of Information Technology, Faculty of Arts, Faculty of Physical Education, Faculty of Arts and Information, Faculty of Law, Faculty of Nursing and Faculty of Islamic Studies). As in UOT, the Libyan Ministry of Education has taken control over the enrolment of new students in undergraduate programs. Again, this process

is conducted through a separate system owned by the ministry. Lists of students are distributed in Excel or database files to universities and community colleges.

No system nor e-solution is dedicated to serving graduate studies. None of these systems are integrated with any other system. Other ICT issues, such as laboratories and teaching equipment, are not covered in detail as they are irrelevant to the topic of this research.

b) The implementation of research activities

The implementation of research activities involves research software, support for research work, research laboratories, research equipment, as well as the RIS as administrative support for the research process. In general, there is no complete IS for research activities at the university. Specifically, there is an archive system for books, periodicals, publications, and research in each library at MU, which was developed using PHP. This system plays a vital role in research activities, since most of the academics employed use it for reference. There is also a promising project called the Digital Archive of Misurata University (DAMU) that handles information retrieval regarding research, theses, dissertations, books, published papers, "innovations and university" programs, and "consultancy and university" studies.

As shown in Table 21, there are no e-solutions for any of the refereed journals or periodicals issued by the faculties of the MU. The support for these refereed journals and periodicals is done through MS office suites such as MS Word and Excel. The announcements and calls for papers are accessible via the MU official website, while the submission process is carried out either manually or by email. The contents of the refereed journals and periodicals are stored without the use of a dedicated system. They are available online in PDF format from the MU website without any supporting function, such as search capability, except for the International Journal of Engineering Science and Information Technology which has its own website.

Table 21: Refereed journals and periodicals issued by MU

Journal	Issued by	Online System
The Art Journal	Faculty of Art	None
The Journal of Legal Research	Faculty of Law	None
The Scientific Journal of Education	Faculty of Education	None
The Journal of Science	Faculty of Science	None
Qabas Journal for Islamic Research and Studies	Faculty of Islamic Study	None
The Scientific Journal of Economics	Faculty of Economics and Political Science	None
The Alsatil Scientific Journal	MU	http://al-satil.misuratau.edu.ly/
The Journal of Shamallejnoob	Department of French Literature, Faculty of Arts	None
Journal of the Faculty of Arts and Media	Faculty of Arts and Media	None
International Journal of Engineering Science and Information Technology	MU	http://ijeit.misuratau.edu.ly/

Other business activities involve human resource information systems (HRISs), finance and accounting ISs and administrative ISs. MU is considered to be the first university in Libya to use such ISs for both academic and administrative staff. These ISs were developed by the IT staff within MU-IDC using a Delphi/SQL database. They aim to handle the data related to academic/administrative staff in all administrative, financial and academic procedures. These systems can generate reports in different manners (monthly, quarterly, bi-annually, and annually). Again, these systems are not integrated with other ISs running in the university. Similarly to UOT, there is an IS for students who are awarded a scholarship to study aboard, owned by the Ministry itself. Other tasks related to human resources are carried out either using MS-office (Excel or Access) or by hand. Moreover, there is an IS dealing with contracts. This is a system that collects the offers of companies providing Internet services, subscriptions and types of each service, where crucial information about contracts is stored, such as contract type, the initial and terminal dates of a subscription, the speed of upload and download, and monthly fee.

Finance and accounting are partially computerized. In the faculties, such matters are usually handled by hand or using MS-office, while the main office of finance and accounting uses an in-house application developed by the IT team in MU-IDC using Delphi/SQL. This system handles all financial affairs with the support of MS Office. According to the respondents, the financial affairs system is the most advanced IS running within MU. For the monthly grand program, launched in 2012, the work is partially computerized by the financial IS of MU and manually with the use of computer applications, such as MS Excel in most faculties. There is also an IS developed locally using PHP for the Office of Quality Control at MU in which all graduate students' certificates and transcripts are stored. Again, this system is not integrated with other ISs implemented at MU.

The administrative IS, incorporating a document handling system, is computerized in most offices and faculties, while it is handled manually or using MS-office in a small number of divisions. This system can create and print official letters with the possibility of searching and saving all the letters created (incoming, outgoing and internal), which provides the possibility of information retrieval at any later time. Other systems have been implemented within the university, such as archive systems, the procurement system, warehouse store system, GIS for building and land monitoring, and a smart-card system.

3) Hosting and Data Centre

All of the online systems operate within MU's website. MU's website is hosted by a Libyan company on a dedicated server for each unit. This option provides absolute control over the server, as it can be remotely controlled using administrator privileges. It is thus possible to install and set up any software desired. The server is located in the company. Also, e-mail services and cloud storage are enabled through a Google Suite. Offline systems are run on local servers and these servers are not integrated with each other.

Summaries of the ISs and e-solutions implemented in MU are presented in Table 22 and Table 23, respectively, along with their purpose and present state.

Table 22: Summary of the information systems implemented at MU

No.	Information System	Purpose	State of the System
1.	Student Information System (SIS)	An information management system for educational activities, handling data on students and the needs of students	• The university lacks a unified system supporting all of its educational activities. • The status of the SIS in MU varies from one faculty to another. • In-house: Delphi+ Visual Basic supported by MS Office.
2.	e-learning system (offline version)	Allows students to complete a course, solve exercises or even study without having to be physically present in the lecture hall. It also complements the traditional teaching process by enabling blended learning.	No such program at all
3.	Enrolment of new undergraduate students (offline version)	Designed to register new students and manage their needs	• Handled by the Ministry • Partially computerized using MS Excel and MS Access
4.	Monthly grand system	Managing monthly grand program for undergraduate students	Partially-computerized by the financial IS supported by MS Office
5.	Library system	Management Information System for Library	All faculty libraries run non-integrated software packages
6.	Laboratories	A special system designed for laboratories.	None
7.	Virtual libraries and simulation systems	Advanced technology aimed to improve teaching and students' learning experience	None
8.	Research Information System (RIS)	A database or other information system storing and managing data about the research conducted at an institution	None
9.	Digital Archive (offline version)	Uploading and managing material regarding research, theses and dissertations, books and published papers.	Purchased open-source software package
10.	E-solutions for refereed journals and periodicals (publishing IS)	Uploading and managing the journals and periodicals issued by the university	Partially computerized using MS Excel and MS Access
11.	Human resources	Handling information needed for the management of human resources within the university	Partially computerized using MS Excel and MS Access
12.	Finance and accounting	Dealing with financial affairs	• In-house: Delphi • Supported by MS Excel and MS Access
13.	Document Management	Tracking, managing and storing documents, letters, and official correspondence	Partially computerized

14.	Sales IS	IS adapted to selling services and products, such as books published by the university	Computerized
15.	Decision Support System	Supporting business or organizational decision-making activities.	None
16.	Graduate Information system	Handling the activities related to graduate study	None

Table 23: Summary of sub-business processes and the relevant e-solutions

No.	Sub-business process	E-solution	Status of the System
1.	Student Online Registration System	Yes	Some faculties use an online system that was developed by the IDC's IT team.
2.	E-learning system	No	None
3.	Enrolment of new students (undergraduate)	No	Handled by the Ministry itself, supported by MS Office suites such as Excel and Access
4.	Monthly grand system	No	None
5.	Digital Archive	Yes	Purchased open-source software package as part of the university's website using PHP
6.	E-solutions for refereed journals and periodicals	No	See Table 21
7.	Human resources	No	None
8.	Finance and accounting	No	None
9.	Network resource management	No	None
10.	Document Management	No	None
11.	Sales	No	None
12.	Library system	No	None
13.	Laboratories	No	None
14.	Virtual libraries and simulation systems	No	None

6.6. Case Study III - Sirte University

6.6.1. About the Case Study

Sirte University (abbreviated to SU) is a Libyan public university, located in the city of Sirte. SU was established in 1989 as a branch of Benghazi University. In 1992, it became an independent university under the name "Attahadi University". In 2010, it changed its name to Sirte University. SU is one of the most prominent scientific institutions in Libya. The University has 13 faculties, which are located in the City of Sirte (in the center of Libya's northern coast) and District of Al-Jafra (240km to the south). The number of registered students is 14857, the number of teaching and scientific staff is 544, of whom 370 are Libyans and 174 are foreigners. There are 227 cooperating professors and 1461 administrative staff and technicians (SU, 2019) (S-1, 2019). The faculties in SU are:

- Faculty of Science
- Faculty of Economics

- Faculty of Economics- Hun[1]
- Faculty of Education
- Faculty of Education - Hun
- Faculty of Medical Sciences
- Faculty of Law
- Faculty of Agriculture
- Faculty of Arts
- Faculty of Human Medicine
- Faculty of Dentistry
- Faculty of Information Technology
- Faculty of Nursing

Also, SU runs 3 regular scientific conferences and 4 journals, all of which are approved by the Libyan National Book House. The degrees granted by SU are: Bachelor of Science (more than 90 areas of study) and 3 Master degrees. However, SU has recently signed a contract to launch a branch of The Academy of Graduate Studies (Tripoli)[2] (SU, 2019).

6.6.2. The Case Study Respondents

The pool of contacts was expanded using snowball sampling/RDS based on participants' recommendations. Three participants, labeled S-1, S-2 and S-3, were contacted. The details of these respondents are given in Table 24. The author carried out the interview process with these respondents during June – August 2019. Specifically, the respondents were first introduced to the study via e-mail at the beginning of June. They were then contacted by telephone for the first session of the interviews. After this, a list of the additional information needed was e-mailed to them. Eventually, oral sessions were held to conclude the interviews in Libya in the period 20th July – 5th August. The languages used in the interviews were Arabic and English for easier communication with the respondents. The length of these interviews was between 35 minutes and 2:15 hours. S-1 was the initial seed of the sequence of interviews. He proposed two participants, namely: the Head of the Programming and System Analysis Office (S-2) and the Director of the Website Design and Management Unit, since the target ICT component was the level of IS implementation rather than the overall ICT level.

[1] The town of Hun is the capital of the Al-Jufra District.
[2] The Libyan Academy of Graduate Studies is a public institute for graduate studies and research that was founded in 1988 under the name "Graduate Institute of Economic Sciences".

Table 24: Summary of respondents participating in the SU case study

Respondents	Position	Years of Experience
S-1	Director of Information and Documentation Centre (ITDC)	9
S-2	Head of the Programming and System Analysis Office in the ITDC	5
S-3	Director of the Website Design and Management Unit	3

6.6.3. Findings from SU[1]

1) The Information Technology and Documentation Centre (ITDC) at SU

The ITDC of the university was established in 2005 by a decision of the Presidency of the University and was reorganized according to the new structure of the university to include some of the functions of the Office of Media and Documentation. It was renamed as the Center for Information Technology and Documentation. It is divided into 3 units with 19 employees as follows:

- Unit of the Director:
  - Director of ITDC.
  - Administrative affairs.
- Unit of Information Management:
  - Office of the Design and Management of SU's Websites.
  - Office of Archives, Mechanization and Printing.
  - Office of Statistics and Evaluation.
  - Office of Translation and Language Review.
  - Office of Media and Press.
- Units of Mechanization and Maintenance:
  - Office of Maintenance and Technical Support.
  - Office of Design and Management of Networks.
  - Office of Programming and Systems Analysis.
  - Office of Training and Development.
  - Office of Telecommunications.

Similar to the other case studies, there is also an employee in each faculty who is responsible for informatics issues and works as a mediator between the ITDC and the faculty. Besides this, there are a number of staff responsible for data entry and this number varies based on the size of the faculty and is generally between 2-5 people.

2) Business Activities in SU and Associated Information Systems at SU

[1] All these findings are from the interviews (S-1, 2019) (S-2, 2019) (S-3, 2019), unless indicated otherwise.

a) The implementation of educational activities

Such business activities require/consist of the following: portals and forums for e-learning, a virtual library, library system, laboratories, teaching equipment, and administrative support for the education process in the form of an SIS. Similar to the other case studies, SU lacks an IS integrated across all faculties to support educational activities. Each faculty runs its own version of a student information system. This was developed by an external party using Delphi with an SQL database that runs on an MS Windows Platform. All of the faculties rely on the same system, while a small number of faculties still use paperwork for some functions. These versions of the SIS are not integrated, which means that no direct connections have been established via a network. In all of these systems, reports are generated with the support of MS Office applications. As is the situation in MU, there is no program for e-learning at SU. One noticeable issue is that the duplication of systems is very rare in SU, which is unlike the other universities in this study. S-2 stated that SU and the University of Benghazi are the only two universities in the whole country that do not experience a serious problem with duplicated systems[1]. All of the faculties rely on the same system. However, there are other issues with this system, due to it being developed by an external party. Although SU owns the source-code, maintenance is still the responsibility of the developing party. This is a serious issue, especially as the contract will finish in 2023. For libraries, each faculty runs its own copy of a Library Management System. Again, these copies of the system are not integrated. The system was developed internally by the IT team of the ITDC using PHP and MySQL. As in the other cases, the Libyan Ministry of Education has taken control over the enrolment of new students in undergraduate programs.

None of the systems mentioned above are available online. Unlike the other two cases, there is no online registration system that enables students to manage their course programs. For educational activities, SU's website is used to advertise to and inform staff, students and other stakeholders. Also, the exchange of information between the website and the older offline systems (placed on local servers in the faculties) is operated manually using Excel/SQL files, which is common practice in all three cases. The university's website is available in both Arabic and English. The current version of the website was programmed from scratch using the PHP language by a programming team in the SU-ITDC. The university website does not provide accurate data. There is no integration with the university's internal systems. Again, data is transferred manually from/to the website. Similarly to MU, a number of websites have been designed for some faculties and offices in SU.

[1] This is based on S-2's working experience with the National Committee for ICT in LHE, which was established by the Libyan Ministry of Education.

No IS or e-solution is dedicated to graduate studies. Instead, MS Office is used to support the sub-business activities in this area. Other ICT issues, such as laboratories and teaching equipment, are not covered in detail, as they are not relevant to the topic of this research.

b) The implementation of research activities

The implementation of research activities involves research software, support for research work, research laboratories, research equipment, and RIS as administrative support for the research process. Similarly to the other cases, there is no integrated IS for research activities at the university. Instead, there are separate solutions for research activities. Most research activities are supported by MS Office applications, while very few of them are supported by in-house applications. As shown in Table 25, there are no e-solutions for the journals and periodicals issued by the faculties of SU. All of these refereed journals and periodicals are processed without the support of an IS. The only support for these refereed journals and periodicals is via MS Office suites (Word and Excel). Announcements and calls for papers are made through the SU's official website, while the submission process is carried out either manually or by e-mail. These journals and periodicals are accessible online in PDF format on the SU website without any supporting function, such as search capability.

Table 25: Refereed journals and periodicals issued by SU

Journal	Issued by	Online System
The Art Journal	Faculty of Art	None
The Journal of Legal Research	Faculty of Law	None
The Scientific Journal of SU	SU	None
The Scientific Journal of Economics Studies	Faculty of Economics and Political Science	None

Accessibility to these journals is through a digital archive that is a component of the SU website. In this archive system, users can find books, official documents, periodicals, publications, and research produced by SU. This was developed using PHP and MySQL and plays a vital role in research activities, since most of the scholars working at SU use it for reference. Also, there is an in-house system for libraries, such that each of the libraries owns a copy of the Library Management System. Again, these copies of the system are not integrated. Also, the university runs an electronic portal. Any staff member or student can create their own account. This system allows them to have a university e-mail address that can be used to access international journals and periodicals. At present, this system is limited to adding or modifying personal data, while other services are being developed.

Other business activities involve HRISs, finance and accounting ISs and administrative ISs. Unlike UOT and MU, SU lacks any IS to handle these activities. Such business activities are supported by MS Office (Excel and Access) applications. In both the faculties and the main office, such matters are usually handled by hand or using MS

Office. They are able to generate reports used for decision making in various manners (monthly, quarterly, bi-annually, and annually). None of these systems are integrated with the other ISs implemented in the university. There is also a basic system for handling administrative documents that is computerized in some offices and faculties. However, such documents are handled manually or using MS Office in other divisions.

Similarly to the situation in both UOT and MU, there is an IS for students who are awarded a scholarship to study aboard, managed by the Ministry itself. Other business activities are handled either using MS-office (Excel or Access) or by hand.

3) Hosting and Data Centre

All offline systems are stored on local servers. As mentioned previously, SU possesses an SIS for all of its faculties that was developed by an external party. These offline systems are not integrated and communicate with each other or with the SU online system though the manual exchange of data, e.g. in the form of SQL files. On the other hand, all of the online systems operate on SU's website. SU's website is hosted by a Libyan company called "The Libyan Spider" with a server dedicated to each unit. Similar to MU and UOT, this option provides absolute control over the server, as it can be remotely controlled using administrator privileges. It is thus possible to install any software desired. The server is located in the company. As in MU, e-mail service and cloud storage is carried out via a Google Suite.

Summaries of the ISs and e-solutions implemented in SU are presented in Table 26 and Table 27, respectively, along with their purpose and present state.

Table 26: Summary of the information systems implemented at SU

No.	Information System	Purpose	State of the System
1.	Student Information System (SIS)	Information management system for educational activities, handling data on students and the needs of students	• The university lacks an integrated system supporting its educational activities. • All faculties run the same SIS • Purchased IS: based on Delphi supported by MS Office.
2.	e-learning system (offline version)	Allows students to complete a course, solve exercises or even study without having to be physically present in the lecture hall. It also complements the traditional teaching process by introducing blended learning.	No such system at all
3.	Enrolment of new undergraduate students (offline version)	Designed to register new students and manage their needs	• Handled by the Ministry • Partially computerized using MS Excel and MS Access

4.	Monthly grand system	Managing monthly grand program for undergraduate students	Tasks performed with the support of MS Office
5.	Library system	Management Information System for Library	All faculty libraries run non-integrated software packages developed by SU
6.	Laboratories	A special system designed for laboratories.	None
7.	Virtual libraries and simulation systems	Advanced technology meant to improve teaching and students' learning experience	None
8.	Research Information System (RIS)	A database or other information system to store and manage data about research conducted at an institution	None
9.	Digital Archive (offline version)	Uploading and managing material regarding research, theses and dissertations, books and published papers.	Tasks performed with the support of MS Office
10.	e-solutions for refereed journals and periodicals (publishing IS)	Uploading and managing the journals and periodicals issued by the university	Partially computerized using MS Excel and MS Access
11.	Human resources	Handling information needed for the management of human resources within the university	Tasks performed with the support of MS Office
12.	Finance and accounting	Dealing with financial affairs	Tasks performed with the support of MS Office
13.	Document Management	Tracking, managing and storing documents, letters, and official correspondence	Partially computerized with the support of MS Office
14.	Sales IS	IS adapted to sell services and products, such as books published by the university	None
15.	Decision Support System	Supporting business or organizational decision-making activities.	None
16.	Graduate Information system	The system is for managing graduate studies	None

Table 27: Summary of sub-business processes and the relevant e-solutions

No.	Sub-business process	E-solution	Status of the System
1.	Student Online Registration System	Yes	At present, the system only handles the personal data of students and e-mail services
2.	e-learning system	No	None
3.	Enrolment of new undergraduate students	No	Handled by the ministry itself with the support of MS Office suites, such as Excel and Access
4.	Monthly grand system	No	None
5.	Digital Archive	No	None
6.	e-solutions for refereed journals and periodicals	No	See Table 25
7.	Human resources	No	None
8.	Finance and accounting	No	None
9.	Network resource management	No	None
10.	Document Management	No	None
11.	Sales	No	None
12.	Library system	No	None
13.	Laboratories	No	None

14.	Virtual libraries and simulation systems	No	None

6.7. Summary

This chapter has presented the fieldwork in Libya. Three public universities from LHE were investigated as case studies to assess the functioning of the ISs supporting their business and associated sub-business activities. In order to study these cases using a consistent basis, the model of business activities in HE institutes presented by (Zornada & Velkavrh, 2005) was adopted. First, other methodological aspects of the study, such as sampling and the target population, were introduced. A brief background of Libya and LHE were also given. For each university, a short introduction, a description of the respondents, the findings from the case study and an assessment of the ISs implemented were all presented. Also, the reasons for considering UOT in an initial study were presented. In the next chapter, analysis and discussion of these findings are provided on the basis of the assessment framework.

CHAPTER SEVEN: ANALYSIS AND DISCUSSION

7.1. Introduction

Over the past decade, a number of approaches with a variety of techniques and models have been developed in the field of IS to investigate issues in an organization related to IT in general. In this part of the study, an analysis of the findings and further discussions are presented using the assessment framework explained in *Chapter Five: Hypotheses and the Assessment Framework*. The techniques and models used in this assessment framework were applied taking into account that technological and organizational levels in a developing country such as Libya differ from those countries in which these models were originally developed and tested. The system profiling and process mapping of ISs, as well as analysis based on various models, provided the author with an effective way to compare IS levels in each case study, as well as giving the reader deeper insight and understanding of the research findings.

As illustrated in Figure 11, there are five steps in the assessment framework, progressing from general to more detailed analyses. The level of the ISs implemented will be evaluated using the assessment framework. Deeper discussions are provided where necessary.

7.2. Case Study I: The Initial Study on University of Tripoli

7.2.1. STEP 1: Interviews with Experts at UOT – Assessment of IS Performance

As shown in Table 28, assessment was conducted on the basis of in depth interviews with local experts on the implementation of ISs in the university taking into consideration the assessment criteria stated in Table 10.

Table 28: Summarized responses from the UOT case study

Criteria	T-1	T-2	T-3
Ease and simplicity of use	Most of the ISs are easy to use	Agreed with T-1	Agreed with T-1
Technologies used	The purchased software packages from international companies are up-to-date, while other in-house applications are not cutting edge technology	Office 365 is the only up-to-date IS	The IT development team is struggling to maintain in-house applications based on international standards
Coverage of business and sub-business activities	Some business and sub-business processes are partially computerized using MS Excel and Access with strongly limited opportunities for adaptation	Only the SIS has a fully functional online version. This was developed as an in-house application	The installed systems are far from covering all business and sub-business activities

System Integration	Not all active applications are connected to each other. There are no software bridges.	To exchange data between systems, manual work is necessary.	Data transferred in MS Excel format, CSV and database format
Availability of services	Online systems are available anywhere and anytime	Offline systems are limited to the divisions in which they are implemented	In-house applications are available only in the unit where they were developed
Efficiency and reliability of the information provided	Very little information is available immediately on request.	Information is reliable, but the availability does not meet desired standards	Information from both purchased and in-house applications is reliable, but most of the time it is not obtainable quickly, due to the lack of integration between systems
The capability of developing ISs	The current IT staff have too great a workload	More qualified IT staff are needed, especially developers Strong time constraints on the possibilities of training the IT staff.	Development processes need to be split into small projects and some of the tasks outsourced to a third party to accelerate the process.
Challenges to improving the current ISs	Neither the in-house systems nor purchased ones are well-documented	In-house applications are out-of-date since software documentation is not fully available	Some purchased applications cannot be modified
Implementation of purchased open-source software	Reduces the time taken to develop a system compared to developing a system from scratch	Local vendors do not meet international levels, while international vendors are difficult to contract due to the current instability of the country	Agreed with T1 and T2

The responses of the experts concerning their assessment of the current level of the ISs deployed in UOT are summarized below. Although all three respondents agreed on the low-level of ICT in general and the ISs implemented in particular, some points were mentioned as strengths based on the current status.

- ISs reduce the time needed and errors occurring during the carrying out of business activities by eliminating unnecessary procedures. A good example, which was given by respondent T-3, is that the new online systems enable students to register at any time or place for courses, while the top management of UOT is aware of all online activities during the registration period.
- The business process and sub-business activities supported by ISs are completed faster and more accurately with reliable information provided, as expected.
- Although top management appears not to be satisfied with the existing ISs, the university is not ready to invest more in IT. Top management is convinced that most

of the business and sub-business activities need applications based on the latest technology, but is worried about the consequent costs.

- There has been a noticeable improvement in the reliability of information gathered in business activities due to the use of ISs, which is reflected in better decision-making. This improvement is limited, since the reports generated from the ISs implemented are not available instantly as required by top management. Most of them are transferred in paper format or by converting them into other files, such as MS Excel or Access.
- In-house applications are not easy to adapt to other business activities or cannot be re-implemented in similar divisions to the original department where those applications were originally developed.
- In-house applications were developed using a variety of technologies and run on several different platforms, which makes it impossible to integrate them into a single connected architecture. The same situation is apparent regarding purchased applications that come from different vendors with different technologies, but is even worse since some of these applications are not editable.
- More qualified staff are required, which is not possible within the unique environment of the university. In fact, the current development team is unable to troubleshoot all of the systems currently running, which is reflected in limitations on the results expected from these systems.
- There is a lack of records regarding the ISs, such as software documentation, records of errors.
- A very interesting finding is that UOT was considering the adoption of the SIS developed by the University of Benghazi[1] before developing their current SIS themselves. Also, Al-Mergib University[2] and Bani Waleed University[3] recently adopted the SIS developed by UOT. The contract includes training IT staff in these two universities to use the source code, e.g. to troubleshoot the system. This indicates a selling point of the proposed approach, which confirms that cooperation in IT has already been established between Libyan public universities.
- Generally, the level of technology in Libya is low, which should be considered before adopting advanced systems.

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[1] Formerly known as Garyounis University, the University of Benghazi is a public university located in the city of Benghazi and one of the most important institutes of higher education in Libya. Benghazi is the second largest city in the country. The university was founded in 1955 as the University of Libya.

[2] Al-Mergib University is a public university located in Al Khums, Libya. It was previously known as Intifada University and Nasser University.

[3] Bani Waleed University is a public university located in the town of Bani Waleed, Libya. It was previously a group of colleges within Misurata University before becoming an independent university in 2015.

7.2.2. STEP 2: Analysis of the Growth of IT and the Overall Level of ISs at UOT on the Basis of Nolan's Model

As shown in Figure 16, the first stage in Nolan's Model is "initiation", in which the automation of labor-intensive operations is carried out, to reduce costs and increase efficiency. All of the sections of UOT are already beyond this stage. Indeed, UOT's top management, and even the authorities in the faculties are pushing toward adopting the best available technologies.

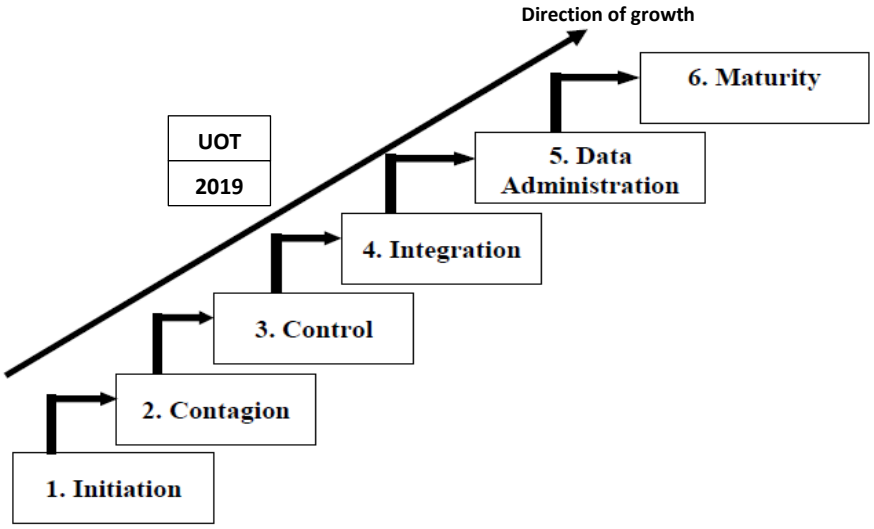


Figure 16: An assessment of the development of IS implementation at UOT based on Nolan's model

"Contagion" is the second stage, when an organization becomes more familiar with the possibilities that automation gives. There is an increasing desire for other sorts of systems (technologies). UOT is already beyond this stage as well. All of the departments and divisions use information technology, ISs and software applications to carry out tasks faster and more reliably. Links between ISs within the same department have already been launched by various means.

"Control" is the stage following the spread of automation systems throughout an organization and the failures encountered in the "Contagion" stage. Some of the ISs deployed in UOT were replicated in various departments. The actions taken by UOT's top management to unify the online registration system are a good example of this. Before, each faculty had a different course registration system. Some faculties with a small number of students, such as the Faculty of Pharmacy, were using MS Excel or Access to handle such business processes, while others, such as the Faculty of Information Technology and the Faculty of Economics were using in-house applications developed by their IT staff.

However, we cannot say that UOT has passed through the "Control" stage, since there are still some systems that are replicated in various departments, such as the document management system. At the same time, UOT is already in the next stage, that of

"Integration", since the university is planning to manage all of its business processes and sub-processes using integrated information systems. Currently, there is a tendency to carry out services with the support of in-house applications implemented using computer software such as MS Excel or Access. As a result, the author sees the level of ICT, especially the implementation of ISs, as being between the "Control" and "Integration" stage, since in 2012 there was a shift at UOT to control the growth of ICT.

7.2.3. STEP 3: Assessment of the Implementation of ISs at UOT in Business Activities on the Basis of Zuboff's Model

A number of offline and online ISs are deployed to serve the implementation of educational activities and give administrative support for the education process. Some of them are in-house applications, while others are purchased software. Although a number of these systems are out-of-date and need to be replaced, faculties are still using them to support their business activities. These systems do not fully "Automate" the entire set of educational activities. The reports generated from these systems are used in the decision-making processes carried out by the relevant authorities in faculties. Also, the top management of the university makes use of these reports for strategic decision support in crucial matters, such as deciding the number of new laboratories or buildings to be built. These reports are generated on a daily, weekly, monthly or quarterly basis. The only educational activity that has been transformed into a fully-automated process is course registration.

The implementation of ISs related to research activities and administrative support for the research process is a step behind. Library management ISs are available to serve both research activities and some of the journals published by the university. All the library management ISs are purchased packages, while some of the journal systems are in-house developed. Valuable information is obtainable from these systems to support decision-makers in research activities, e.g. statistics representing the current status of research. Other business activities receive less attention in the form of very limited ISs being implemented to serve activities such as HR or financial activities, as shown in Figure 17. This leads to much less information being available to the decision-makers dealing with these business activities.

Figure 17 presents an overall analysis of the adoption of ISs at UOT on the basis of Zuboff's Model. Educational activities and administrative support for the education process are the only processes among the university's core functions to be facilitated by advanced ISs. Despite this, both new ISs and enhancement of the current ISs are needed to fully "Transformate" the servicing of educational activities. It is clear that the support of both research activities and other business activities does not meet the requirements of "Transformating" all of the related activities to be electronic.

Business Activities	**Automate**	**Informate** IT reports	**Transformate**

	Measure technical aspects of IT (rate of information flow, accuracy, timeliness)	and project implementation	Perceivable improvements in service, intangible benefits (trust, loyalty, brand, etc)
The implementation of educational activities and administrative support for the education process	In-house applications are available to serve students, as well as staff, in many business processes, such as course registration or uploading results.	Daily, weekly, monthly, quarterly reports are available and reliable in many parts of the system, which provide accurate information helping the top management of the university or the authorities of the faculties in making decisions.	Only course registration has been transformed into a fully-automated system.
The implementation of research activities and administrative support for the research process	Both in-house applications and purchased software are available for some research activities, such as journal websites and libraries.	Partially reliable information is obtainable from reports generated by websites for the journals published by the university.	
The implementation of other business activities, such as HR management, sales, finance or documentation	Some systems are available, such as a HRIS for the administration of academic staff, finance IS, network resource management system and document management system	Very limited reports are obtainable from these ISs. Top management uses these reports during the preparation of the annual financial accounts.	

Figure 17: An overall assessment of IS adoption at UOT on the basis of Zuboff's Model

7.2.4. STEP 4: Detailed Assessment of IS Implementation at UOT Using System Profiling and Process Mapping

Generally, there are three main categories of IS used in the business processes at UOT as itemized below:

- In-house applications developed either by the IT development team using a variety of development tools, such as VB/SQL, ASP/SQL Server, C++, and PHP/MySQL. All of these applications are out-of-date, not well documented and have many problematic issues.
- Applications purchased from local vendors. These are either open-source applications or maintained by the vendor. The former are not easy to maintain or develop.
- Access/Excel applications used to support some core activities. These applications are used for organizing tasks and storing and retrieving data. They are also used to generate better quality reports from data obtained from other ISs.
- Integration between these systems is limited to manual communication. There is no bridging software at all. Data are transferred in a format such as Excel, CSV, database files or even re-entered manually in some cases.

Specifically, with regard to (1) educational activities and administrative support for the education process: only the SIS has a fully functional system, which was developed as an in-house application. However, it needs to be enhanced to include more advanced technology. It is the only IS implemented at UOT that is ranked as high as "II". Indeed, as shown in Figure 18, most of the systems implemented to support the sub-business processes of educational activities are ranked "IV", which indicates that a system is currently functional, but insufficient and needs to be replaced. Also, it is obvious that some important sub-business processes do not have any kind of functional IS, such as e-learning whose system is no longer functional. Also, there are no virtual libraries or simulation systems. Overall, educational activities have the most advanced systems among all three categories of business activities at UOT. Figure 18 presents a process mapping for educational activities and their administrative support at UOT giving the rating of the ISs supporting each process.

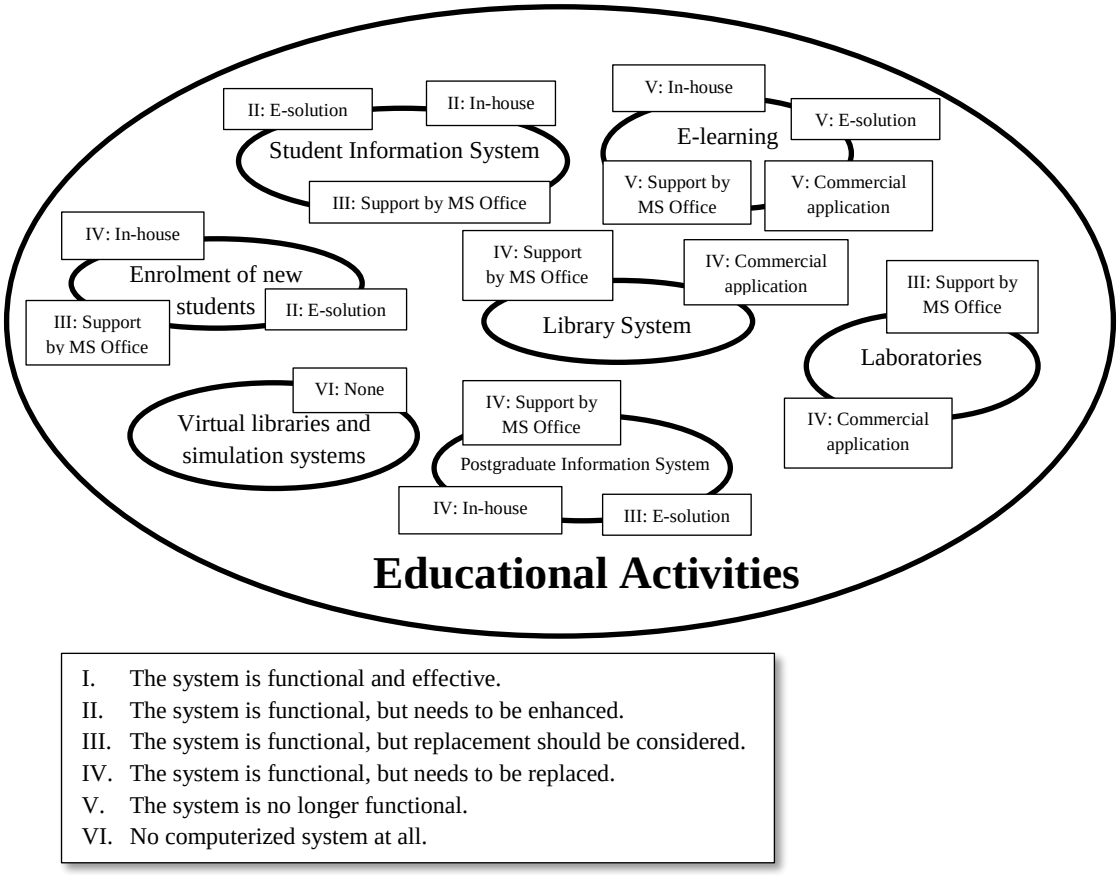
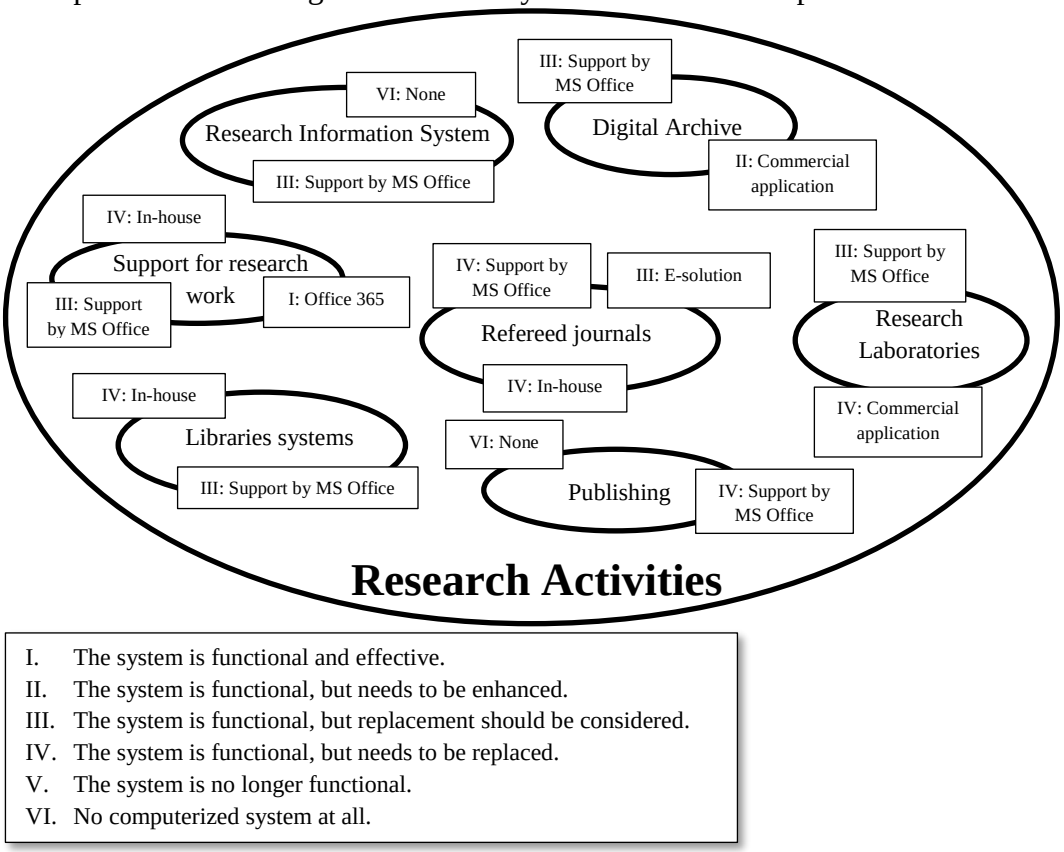


Figure 18: Process mapping for educational activities and administrative support for the education process at UOT

(2) Research activities and administrative support for the research process: Office 365 is the only system is labeled with "I" in any kind of IS in UOT, which indicates the system is functional and sufficient, while the purchased system for the digital archive is functional but needs some enhancement. The rest of the ISs implemented for other kinds of research processes are all rated below "II". This reflects the weak status of IS support for research

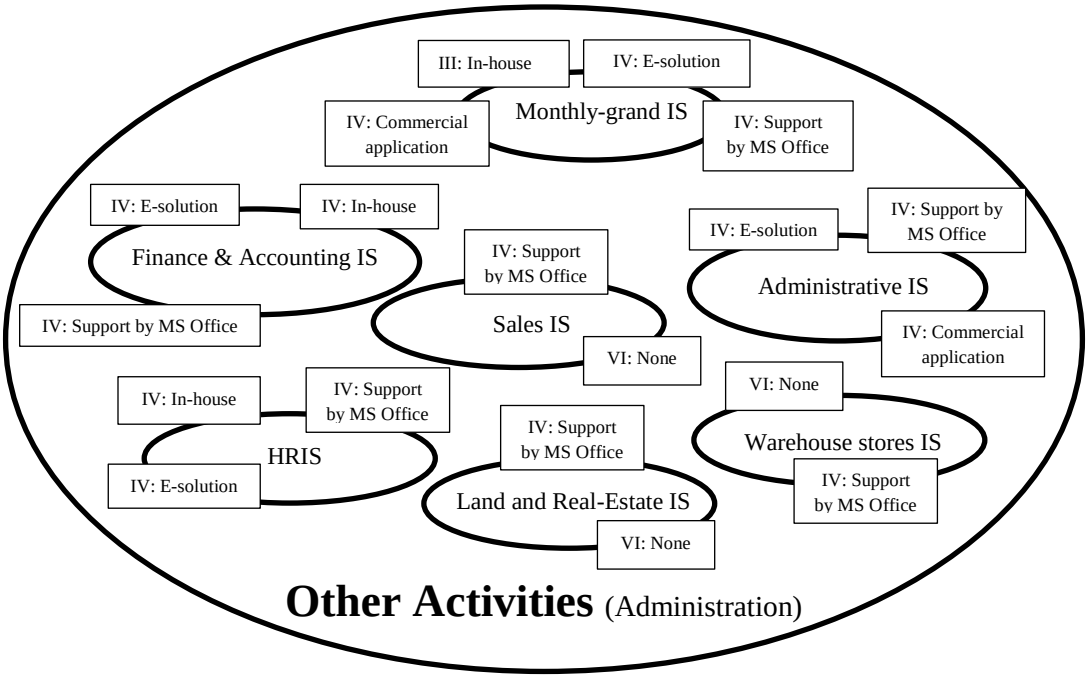
activities and administrative support for the research process at UOT. Figure 19 below represents the process mapping for research activities and administrative support for the research process at UOT together with the system status for each process.



I. The system is functional and effective.
II. The system is functional, but needs to be enhanced.
III. The system is functional, but replacement should be considered.
IV. The system is functional, but needs to be replaced.
V. The system is no longer functional.
VI. No computerized system at all.

Figure 19: Process mapping for research activities and administrative support for the research process at UOT

(3) Other processes: All of the ISs implemented for other kinds of business activities are all rated below "II". This reflects the fact that these systems are the least technologically advanced among the three categories of ISs implemented at UOT. Three of the sub-business activities in this category do not even have a computerized system supporting them. The majority of these processes are supported by MS Office including the Sales IS, Warehouse Stores IS and Lands and Real-estate IS. Figure 20 presents the process mapping for other business activities at UOT together with the rating of the ISs supporting each process.



I. The system is functional and effective.
II. The system is functional, but needs to be enhanced.
III. The system is functional, but replacement should be considered.
IV. The system is functional, but needs to be replaced.
V. The system is no longer functional.
VI. No computerized system at all.

Figure 20: Process mapping for other activities (other administrative processes) at UOT

7.2.5. STEP 5: Assessment of Online ISs at UOT on the Basis of the CPIT Model

The analysis of the e-solutions adopted for educational activities at UOT is summarized in Figure 21. Currently, most organizations have an advanced status concerning being "connected" to various technologies, e.g. the use of basic internet technologies, such as email services, is now a fundamental part of any organization's functioning. In UOT, basic Internet technologies are found everywhere. One of them is the "Office 365" project, via which all students, academic staff and administrative employees are offered e-mail services. Using such e-mail services, staff and students are easily reachable. Also, the network management system accounts are connected with the e-mail system, since privileges (such as limits on Internet use) are determined on the basis of whether the user is a student, employee, academic staff or a visitor, as indicated by the e-mail address. These e-mail services can be used in a variety of ways. An example of this is the exchange of formal letters using registered e-mail services in some parts of the university. Moreover, UOT's main website and other specific-purpose websites - such as the online SIS - provide users with the necessary information, even though there is a desire to enhance the current services. Furthermore, online interaction in educational activities occurs via the online SIS and its services.

Educational activities and administrative support for the education process are based on a partially online technology	Information on educational activities is available online	Interaction is enabled by the online system	
√	√	√	×
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

Figure 21: Assessment of the adoption of e-solutions for educational activities at UOT

Secondly, research activities and administrative support for such activities are based on a partially online technology according to the "Connect" aspect. Accessing international journals via e-mail services in MS Office 365 is a good example of this. This service is rendered to students, academic staff and researchers. Also, information on research activities is available from various online content, such as the online pages of libraries. Interaction is mostly limited to the websites of journals published by the university, where users can interact with the system. Figure 22 summarizes the analysis of the adoption of e-solutions in research activities at UOT.

Research activities and administrative support for research activities are based on a partially online technology	Information on research activities is partially available online	Partial interaction is enabled by an online system	
√	√	√	×
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

Figure 22: Assessment of the adoption of e-solutions in research activities at UOT

Thirdly, concerning the implementation of e-solutions, other business activities in UOT lag behind educational and research activities. Using online communication technologies is limited to the e-mail services offered via MS Office 365. Most information is unavailable online. Such information is limited to the publishing of announcements or advertisements. Figure 23 summarizes the analysis of the adoption of e-solutions in other business activities at UOT.

Other business activities are based on a partially online technology	Information on other business activities is partially available online		

✓	✓	✗	✗
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

Figure 23: Assessment of the adoption of e-solutions in other business activities at UOT

In general, the level of adoption of e-solutions for educational services seems to be beyond the level observed in other business activities in all aspects, with interactive content being available to students and staff via the online SIS system. However, improvement is needed, as stated by each of the experts participating in the study. None of the business activities are close to being served by a fully transformed system, which is represented by the "Transform" aspect in the CPIT model. Unlike in the case of educational and research activities, there is no capability of interaction based on an online system supporting other business activities. Figure 24 illustrates the overall analysis of the adoption of e-solutions at UOT on basis of the CPIT Model.

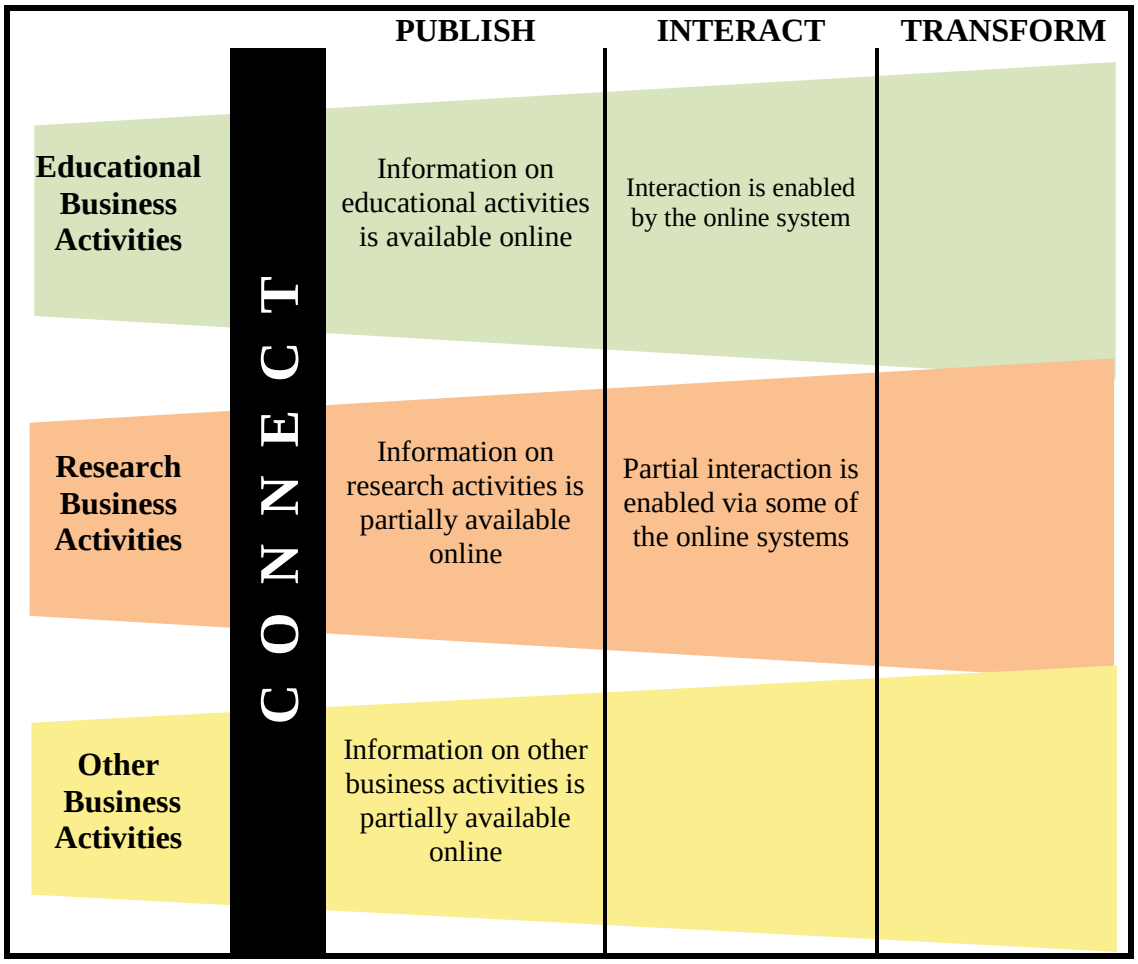


Figure 24: The overall assessment of the adoption of e-solutions at UOT on the basis of the CPIT Model

7.2.6. Lessons Learnt from the Initial Study

In this section, the author would like to summarize the lessons learnt from conducting the initial study. Starting with the purpose of running this initial study in the first place, the initial study can be interpreted as a pre-testing of research techniques and methods, questionnaires and interviews. Identifying practical problems involved in the research procedure, such as instructions and time limits, was also considered to be an objective. Moreover, an initial study helps to project the number of case studies, as well as the minimum number of participants that should be involved in future research. Based on the above, the sampling technique and recruitment strategy were both effective and led to valuable findings. Furthermore, the author was able to analyze the findings on the basis of Zuboff's Model, the CPIT Model, and Nolan's Model. Regarding the practical problems of the research procedure, the initial study took more time than expected and went beyond the planned deadline, partially due to the battle in Tripoli in the summer of 2018. Using online communication was not effective on many occasions and the author was sometimes forced to wait for an answer for days. Also, keeping the online sessions active was not easy. Regarding the number of case studies to be conducted, the initial study discovered that ISs developed by Libyan public universities are already in use within other HE institutes across the country. This indicates the similarity between Libyan universities. Also, the time spent conducting the initial study led to tighter limitations on the time available for further research. As a result, the author chose to carry out a total of three case studies.

Another major lesson learnt from this initial study was the number of participants who should be involved in the formal study. The number of respondents was initially unknown and that is why RDS/Snowballing was used. The initial study indicated that the department responsible for IS implementation is the Department of Information Systems at the ICT Centre where 5 persons are employed, as well as the department head. Besides this, there is a local IT team in the ICT office in each faculty (22 faculties). The number of people working in the ICT office in each faculty varies with a minimum of 3 people. After conducting the initial study, the author assessed the minimum number of participants necessary in other case studies to be two respondents. This was based on the structure of the IT divisions. Interviewing the head of the IT division and the director of the section responsible for the implementation and maintenance of ISs gave a broad overview of the level of ICT within the university.

7.3. Case Study II: Misurata University

7.3.1. STEP 1: Interviews with Experts at MU – Assessment of IS Performance

As shown in Table 29, the assessment was conducted on the basis of interviews with local experts on the implementation of ISs in the university by taking into consideration the assessment criteria stated in Table 10.

Table 29: Summarized responses from MU case study

Criteria	M-1	M-2
Ease and simplicity of use	The ISs themselves are easy to use, the difficulties come from transferring data between non-integrated systems.	Agreed with M-1
Technologies used	It is not easy to keep up with the latest technology especially when in-house applications are used, while purchased suites are updated as long as the contracts with vendors remain valid.	Activities supported by MS Office are the only ones updated continuously
Coverage of business and sub-business activities	Some business and sub-business processes are computerized to a very limited degree using MS Excel and Access. The financial affairs division shows the highest level of coverage with the most advanced use of technologies.	In most business activities, tasks are accomplished either fully or partially using MS Office. Some faculties still use paperwork.
System Integration	None of the systems are integrated by software bridges. Data are transferred either manually or by use of MS Excel or text files. This requires a high level of programming experience	All of the installed systems are far from system integration.
Availability of services	Only the student portal and the MU websites are available online, while offline systems are limited to the divisions in which they are implemented.	Agreed with M-1
Efficiency and reliability of the information provided	Information is reliable to some level, although it is not available instantly upon request since the systems are not integrated	Because of the lack of systems integration, information is not obtainable easily. In some cases, data are imported from systems into MS Office to generate reports manually
The capability of developing ISs	The current team is unable to develop complete integrated systems. More qualified IT staff are needed, especially developers.	We are unable to solve all of the problems we face. Although the center is hiring new staff, they need a long time to learn all of the appropriate technologies. As a result, outsourcing is a better solution.
Challenges to improving the current ISs	Purchased applications are local and the venders could disappear at any point, while in-house applications are out-of-date and difficult to update since software documentation is not fully available	The in-house applications are not documented well enough to be modified by newly hired staff and some purchased applications cannot be modified
Implementation of purchased open-source software	It is faster to install such software. However, there are some concerns such as security, acceptability of the new system to the current staff, difficulty of ERP packages and supportability of Arabic interfaces.	The decision to implement such a system is at a higher level. The relevant persons are not familiar with the technology. As a result, they could see such a project as a large expense rather than a promising solution.

Although the respondents agreed on the low-level of ICT in general and the ISs implemented in particular, some points were mentioned as strengths based on the current

status. Based on the responses gathered during the interviews, the following list summarizes the current state of the ISs at MU and opportunities for updating them:

- The respondents agreed as to the importance of using ISs to support the business activities within the university.
- In-house applications have been developed, either by the MU-IDC's development team or by a faculty team, using a variety of development tools, in particular, Visual Basic and Delphi with a SQL database.
- Applications purchased from local vendors are maintained either by the vendor or by the local IT staff in the case of open-source applications. The latter is not an easy task.
- Use of stand-alone office automation packages: Excel/Access applications used to support some core activities.
- Most of these systems require replacement or at least a major upgrade as all of them are out-of-date, not well documented and have many problematic issues.
- The status of stand-alone systems (offline systems): none of these systems are integrated and data transfer is done manually. There is no bridging software at all. Data are transferred in a format such as Excel, CSV or database files, which requires a high level of programming skills.
- Only the financial affairs division shows a high level of coverage with the widest use of technologies.
- Many systems implemented in MU are duplicated - as is the situation in UOT. Each division has usually either developed or purchased a new system to replace an old system, which has led to a growing number of these systems and data being distributed over different ones. In MU-IDC, they are currently working to solve this problem by unifying all of the working systems.
- Paperwork still appears prior to data entry in most of the systems mentioned before.
- The decision to implement new technology is in the hands of those at a higher level who are difficult to convince of the need to invest more in new technology.

7.3.2. STEP 2: Analysis of the Growth of IT and the Overall Level of ISs at MU on the Basis of Nolan's Model

As shown in Figure 25, MU is already beyond the "initiation" stage, which is fundamental in today's world. MU's top and lower management are aware of ICT's role to provide quality education, although they have some concerns regarding the budget needed for implementing new technology. Moreover, MU has passed through the "Contagion" stage in which ICT becomes widely used to accomplish business activities faster and more reliably and connections become established between different ISs in the same department (in-house applications or those supported by MS Office). It may be stated that MU is at the "Control" stage. Indeed, after the spread of ICT across its

departments, MU is trying to monitor its growth, which is referred to as the control stage in Nolan's model. MU-IDC has already started to construct an integrated IS, including a system managing registration, study and examinations, to avoid the system duplications that occur in many parts of the university.

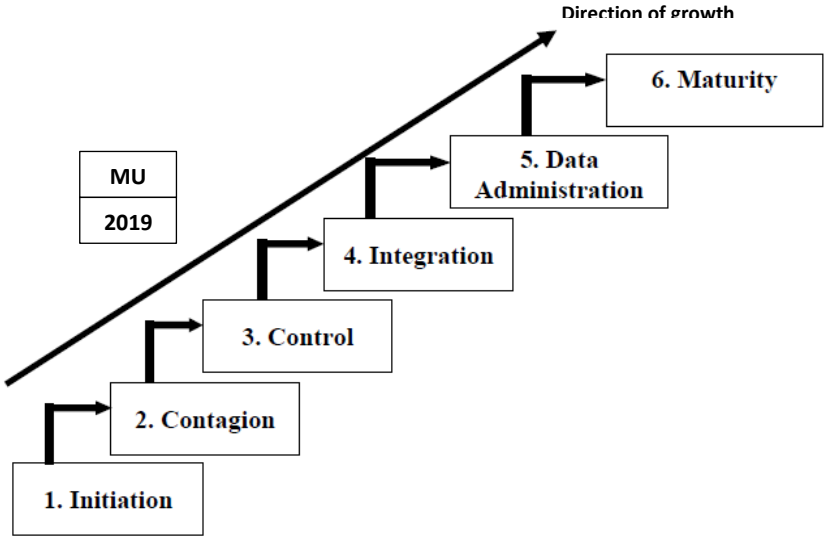


Figure 25: An assessment of the development of IS implementation at MU based on Nolan's model

7.3.3. STEP 3: Assessment of the Implementation of ISs at MU in Business Activities on the Basis of Zuboff's Model

Figure 26 presents an overall assessment of the adoption of ISs at MU on the basis of Zuboff's Model. Generally, most of the business activities are supported in one way or another by an IS in which reports are made available to top management. Although reports are generally made by transferring data from ISs to MS Office, the information provided is reliable and used for decision support. Specifically, financial affairs are the only processes among the university's core functions to be facilitated by advanced ISs. Despite this, new ISs and enhancement of the current ISs are needed to fully "Transformate" the servicing of financial affairs. Support of both research activities and other business activities is still at a very early stage that does not meet the requirements of "Transformating" all the related activities to become electronic. Finally, more efforts are needed to support the implementation of educational activities and administrative support for the education process. For example, online registration systems should be enabled in all of the faculties, as well as launching an e-learning system.

Business Activities	**Automate** Measure technical aspects of IT (rate of information flow, accuracy, timeliness)	**Informate** IT reports and project implementation	**Transformate** Perceivable improvements in service, intangible benefits (trust, loyalty, brand, etc)

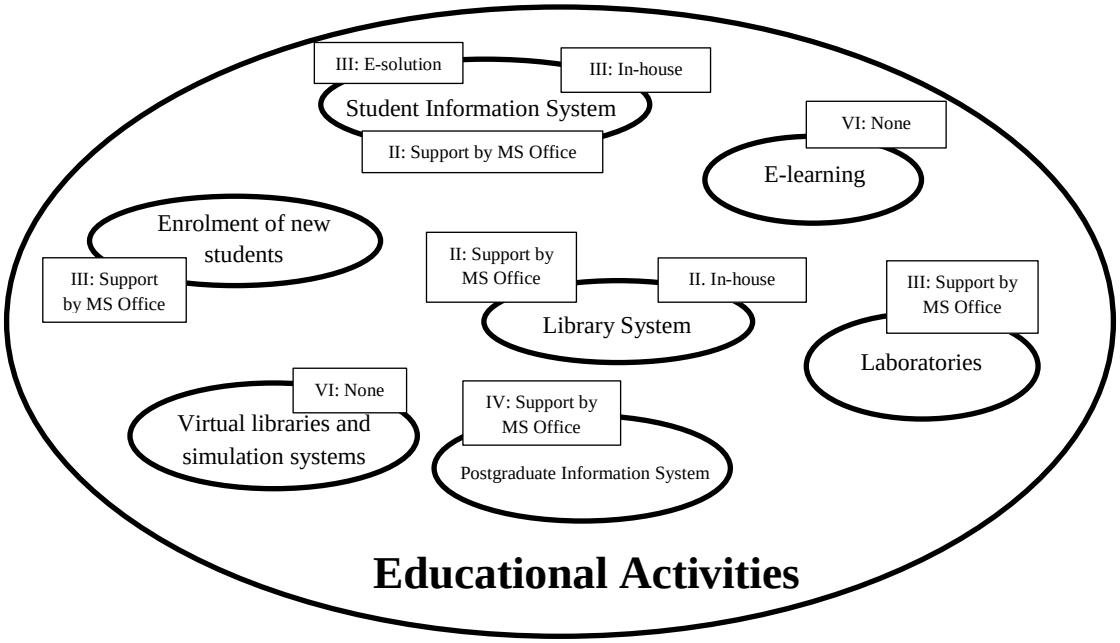
The implementation of educational activities and administrative support for the education process	Both in-house applications and purchased suites (supported by MS Office) are found at MU to serve student management such as course registration. Other activities are accomplished manually in many divisions of MU.	Reports are only available for those educational activities supported by ISs. These reports are accurate although they require a lot of preparation, as they are prepared manually after transferring data to MS Office.	
The implementation of research activities and administrative support for the research process	There is a lack of an integrated IS for research activities at MU. Individual systems are available, such as an archive system for books, periodicals, publications and research in each library at MU.	Partially reliable information is obtainable from reports generated by websites for the journals published by the university.	
The implementation of other business activities, HR management, sales, finance or documentation	Some systems are available, such as an HRIS for the administration of staff, while the financial affairs system is considered to be the best among all the systems.	Reports are obtainable from the financial IS. Top management uses this information to prepare the annual financial report.	

Figure 26: An assessment of the ISs implemented at MU on the basis of Zuboff's Model

7.3.4. STEP 4: Detailed Assessment of IS Implementation at MU Using System profiling and Process Mapping

Generally, there are three main categories of ISs in MU, which is very similar to UOT's situation, namely: in-house applications, purchased suites, and stand-alone office automation packages (MS applications, AutoCAD). Fewer systems of this kind were implemented than in UOT and mostly developed by a third party (commercial applications) using Visual Basic and Delphi. Also, at MU the issue of duplicated systems is only seen in the SIS.

Specifically, (1) educational activities and administrative support for the education process: The university lacks a unified system supporting all of its educational activities. The status of these systems varies from one faculty to another. The only functional online system is a course registration system, which has been implemented in some faculties. No system is ranked as "V", which indicates that the system is no longer functional. However, there is no e-learning program at all. Figure 27 presents the process mapping for educational activities and administrative support for the education process at MU together with an assessment of the systems supporting each process.



I. The system is functional and effective.
II. The system is functional, but needs to be enhanced.
III. The system is functional, but replacement should be considered.
IV. The system is functional, but needs to be replaced.
V. The system is no longer functional.
VI. No computerized system at all.

Figure 27: Process mapping for educational activities and administrative support for the education process at MU

(2) Research activities and administrative support for the research process: MU lacks any kind of RIS, as is the situation in UOT, while the most advanced system is the digital archive. Out of 10 journals, only two possess an online system, while the rest use the university website to publish announcements. This reflects the weak status of IS support for research activities and administrative support for the research process at MU. Figure 27 represents the process mapping for research activities and administrative support for the research process at MU together with an assessment of the systems supporting each process.

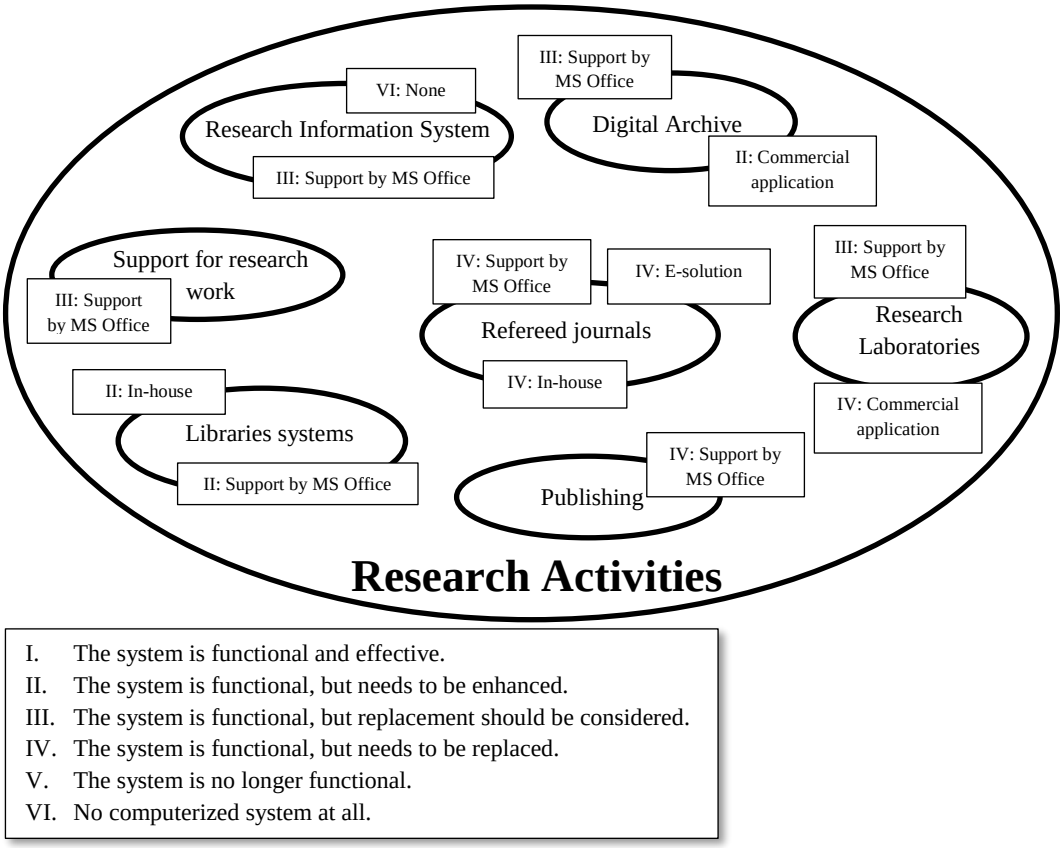
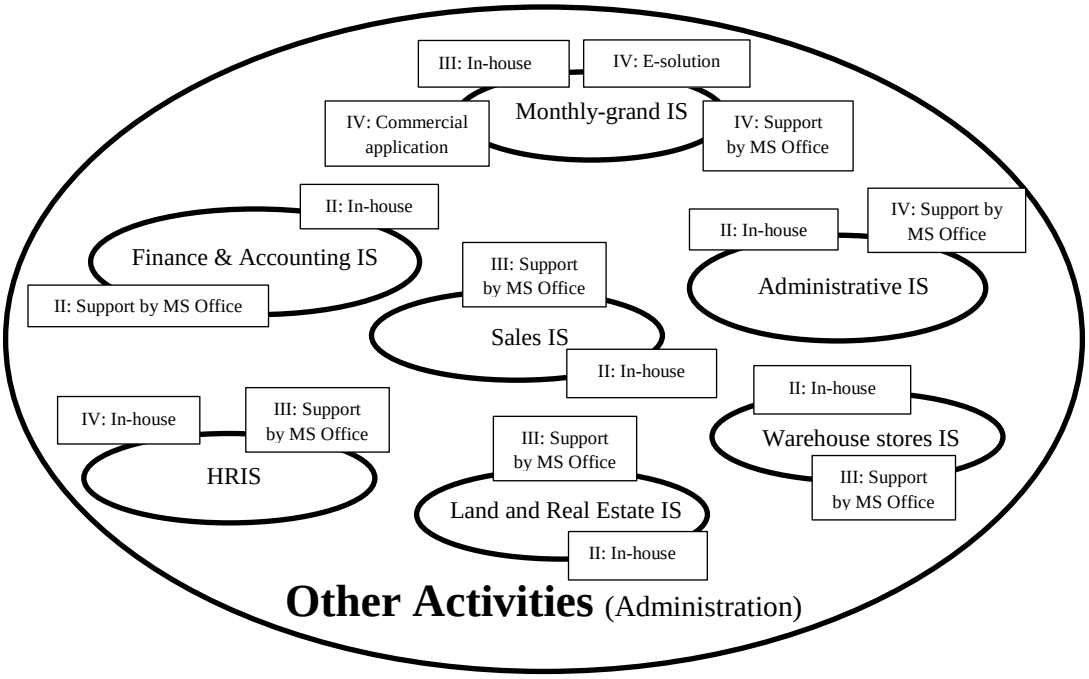


Figure 28: Process mapping for research activities and administrative support for the research process at MU

(2) Other processes: Unlike UOT, other kinds of business activities (rather than educational or research ones) receive the strongest support from ISs. Indeed, the financial IS is the most advanced IS implemented at MU, while the HRIS is considered to be the first such IS implemented in Libya. There is even GIS software for land and real-estate management, a sales IS and warehouse stores IS, which are not found at UOT. None of these systems are integrated. Figure 29 represents the process mapping for other business activities at MU together with an assessment of the systems supporting each process.



I. The system is functional and effective.
II. The system is functional, but needs to be enhanced.
III. The system is functional, but replacement should be considered.
IV. The system is functional, but needs to be replaced.
V. The system is no longer functional.
VI. No computerized system at all.

Figure 29: Process mapping for other activities (other administrative processes) at MU

7.3.5. STEP 5: Assessment of Online ISs at MU on the Basis of the CPIT Model

First, an analysis of the e-solutions adopted for educational activities at MU is illustrated in Figure 30. Nowadays, basic Internet technologies are found at all levels of large organizations, which is the situation at MU. A good example is the use of e-mail services. A number of services have been created for university staff, students and faculty administration. Stakeholders in MU are reachable through these e-mail services. One example of the use of e-mail service is the exchange of formal letters using registered e-mail services that are used in some parts of the university. Moreover, information is obtainable on educational activities via MU's websites, such as the official MU website and the online portal for students. However, the online portal should be enabled in all faculties and enhancement of the current services is also needed. Furthermore, online interaction involving educational activities is only available through the student portal and again this is limited to a number of faculties. Students can interact with the online system to manage their studies, including registering in courses. There is no online content for graduate students at all.

Educational activities and administrative support for the education process are partially online	Information on educational activities is partially available online	Interaction is enabled via the online registration system, and partially via the official MU website	
√	√	√	×
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

Figure 30: Assessment of the adoption of e-solutions for educational activities at MU

Secondly, research activities and administrative support for such activities are based on a partially online technology according to the "Connect" aspect. Information on research activities and its administrative support is available online to some degree, such as via the digital archive of MU and the information on journals published by MU. The latter is also only seen within two journals (namely, the Alsatil Scientific Journal International and the Journal of Engineering Science and Information Technology), while the remaining journals are available as static contents on the university's website. Although there is some interaction, we cannot say that research activities and its administrative support have achieved "Interact" status. This interaction is limited to the exchange of e-mails from/to the two journals mentioned above, rather than an installed function within an online system. Figure 31 summarizes the assessment of the adoption of e-solutions in research activities at MU.

Research activities and administrative support for research activities are based on a partially online technology	Information on research activities is partially available online		
√	√	×	×
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

Figure 31: Assessment of the adoption of e-solutions in research activities at MU

Thirdly, the implementations of e-solutions for other business activities in MU have not even achieved the "Publish" status in most of these activities. The use of online communication technologies is limited to e-mail services only. Most information is unavailable online. In fact, such information is limited to the publishing of announcements or advertisements. Figure 32 summarizes the assessment of the adoption of e-solutions for other business activities at MU.

Other business activities are based on	Information on other business activities is		

a partially online technology	partially available online		
✓	✓	✗	✗
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

Figure 32: Assessment of the adoption of e-solutions in other business activities at MU

Although the financial affairs system is seen as being the most advanced system supporting any of the business activities at MU, this system does not possess an e-solution, unlike the student portal, which has achieved "Interact" status. This confirms the decision of the author to differentiate stand-alone systems (offline) from e-solutions (web-based and available online). As we can see, the offline financial affairs system is more advanced than its online support, while the online student services system is more advanced than offline support. This content is actually the only interactive system at MU. Again, none of these business activities are close to being served by a fully transformed system, which is represented by the "Transform" aspect of the CPIT model. Figure 33 illustrates the overall assessment of the adoption of e-solutions at MU on the basis of the CPIT Model.

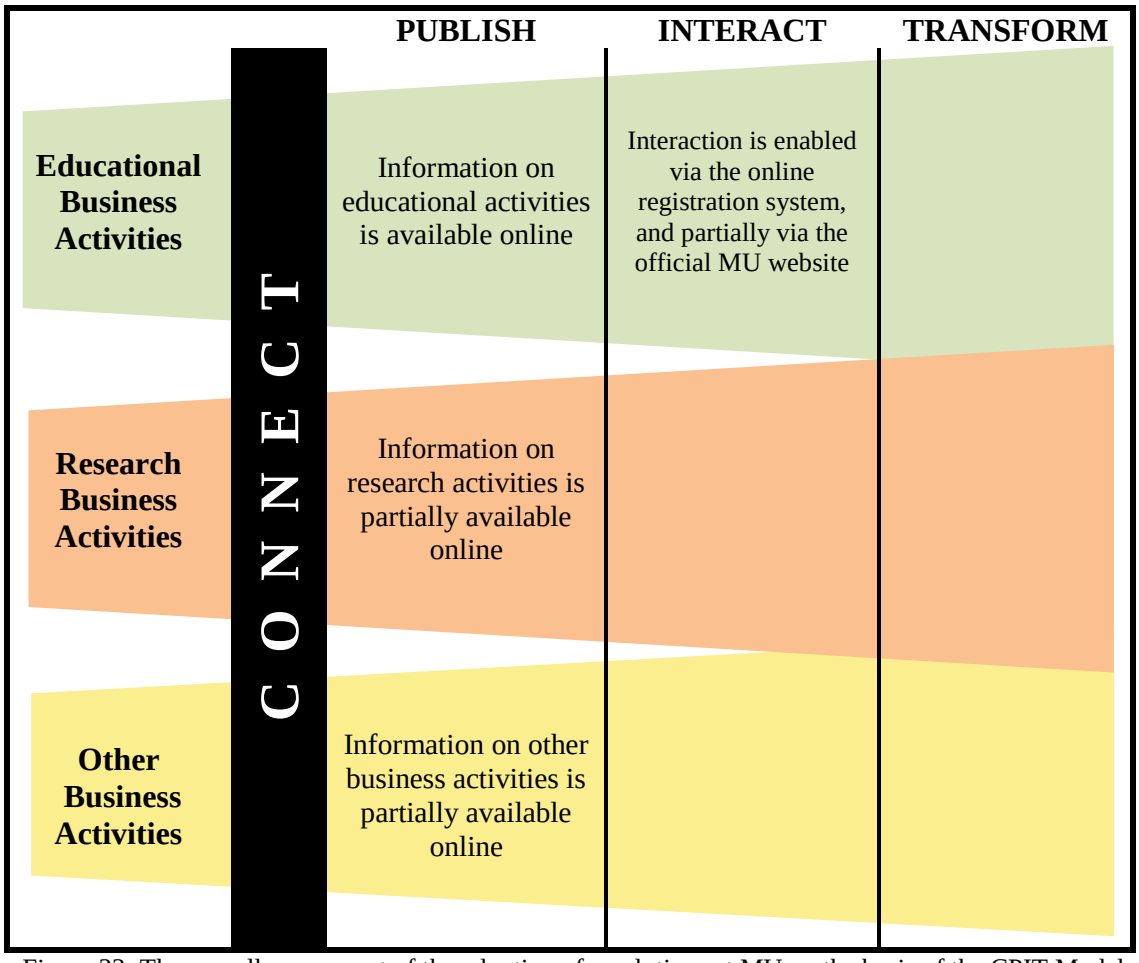


Figure 33: The overall assessment of the adoption of e-solutions at MU on the basis of the CPIT Model

7.4. Case Study III - Sirte University

7.4.1. STEP 1: Interviews with Experts at SU – Assessment of IS Performance

The opinions of local experts on the performance of ISs in the university are summarized in Table 29. Similarly to the other cases, the assessment criteria were taken from Table 10.

Table 30: Summarized responses from SU case study

Criteria	S-1	S-2	S-3
Ease and simplicity of use	The current ISs are easy to use, while trouble-shooting is complicated as it is usually done by the developer	The systems themselves are easy to use, but transferring data between these systems is difficult.	Agreed with S-1 and S-2
Technologies used	The purchased SIS is up-to-date although the contract will terminate in two years and updating might be problematic.	The technologies used are not high level. The university lacks newer technologies, such as a fully online system or mobile applications.	The current SIS has been updated without any problems, although the technology used in this system is not up-to-date.
Coverage of business and sub-business activities	All of the business and sub-business processes are supported by a kind of IS in which using MS Excel and Access is common practice across the university. However, SU lacks completely integrated ISs to support all its business needs.	Only educational activities are supported by an IS that was developed by an external party, while systems supporting research and other business activities are way behind technologically.	In most business activities, tasks are accomplished either fully or partially by MS Office, except for educational activities in which a purchased IS is functional. Even so, paperwork is still being used in many divisions,
System Integration	None of the installed systems are integrated. All data are transferred either manually or by the use of MS Excel or text files between the ISs in SU.	Agreed with S-1.	Agreed with S-1.
Availability of services	The ISs installed around the university are limited to the divisions in which they are implemented.	The university lacks an attractive online system, except for an online portal which is, in fact, a very basic system	Agreed with S-1 and S-2
Efficiency and reliability of the information provided	Although the information provided by the ISs have to be transferred to MS Excel or SPSS to generate reliable reports, this information is considered to be valuable and is used for decision making.	Due to a lack of system integration, the information provided cannot be easily obtained.	The capability for generating reports in the ISs implemented is weak. Instead, data are transferred to other applications for better quality reports

The capability of developing ISs	The university environment is not attractive to professional developers because of the low salaries.	The IT team is unable to solve all the problems. More qualified IT staff, especially developers, are needed. Although the center has new staff, they need a long time to master all the appropriate techniques.	Agreed with S-1 and S-2. In particular, the current team is unable to develop complete integrated systems.
Challenges to improving the current ISs	The SIS contract will terminate in two years, which might mean that updating is problematic.	In-house applications are outdated and difficult to update because the program documentation is not fully available	In-house applications are not well enough documented for modification by newly hired staff and some purchased applications cannot be modified
Implementation of purchased open-source software	You need a good contract with the best matching sellers.	Although there are difficulties in modifying such software to suit the SU environment, I see them as a better solution, especially if other local universities cooperate in such a project.	The budget for purchasing such software is a major challenge, unless there is support from the Ministry itself.

Similar to UOT and MU, the interviewees stated that, in general, there is a need to upgrade the current ISs. The following list summarizes the current status of the ISs implemented in SU and the opportunities for updating them based on the responses collected during the interviews:

- Both in-house applications and purchased ones were developed using different technologies, which makes them difficult to integrate or update.
- Most of these systems need to be replaced, or at least be heavily upgraded, because they are all old, not well documented and involve many problematic issues.
- Lack of integration between systems: None of these systems are integrated and data are transferred manually. There is no bridging software at all. Data are transferred in a format such as Excel, CSV or database files, which requires a high level of programming skills.
- In SU, there are no serious issues regarding the duplication of systems. For example, a version of the same SIS is used in all of the faculties, which is unique among the three case studies. This may well be the result of SU being a newly established university compared to the other two cases.
- The SIS does not have any e-solutions at all, except for a very basic one called the Online SU portal.
- The applications purchased from local vendors are maintained by the developer. Some are maintained locally by SU's IT team, which is a complicated task.

- Use of stand-alone office automation packages is a very common practice across the university: Access/Excel/Access applications are used to support some core activities.
- Paperwork using application forms still appears prior to data entry into many of the systems mentioned above.
- The decision to implement new technology lies at a higher level of management, which means it is difficult to convince decision-makers that investment is worthwhile.

7.4.2. STEP 2: Analysis of the Growth of IT and the Overall Level of ISs at SU on the Basis of Nolan's Model

As is the situation in both UOT and MU, SU has passed through both the "Initiation" and the "Contagion" stages. Technology has spread across the university enabling tasks to be realized more effectively and efficiently. Both top and lower management at SU have a fair knowledge of the importance of ICT in today's world. However, SU is still at the beginning of the "Control" stage. This stage comes after the initial spread of IT across the organization. In fact, SU-ITDC has made an effort to integrate the SIS, which is hardly visible in the long-established UOT. This stage of development is described as the control stage in Nolan's model. Figure 34 presents an assessment of the development of IS implementation at SU based on Nolan's model.

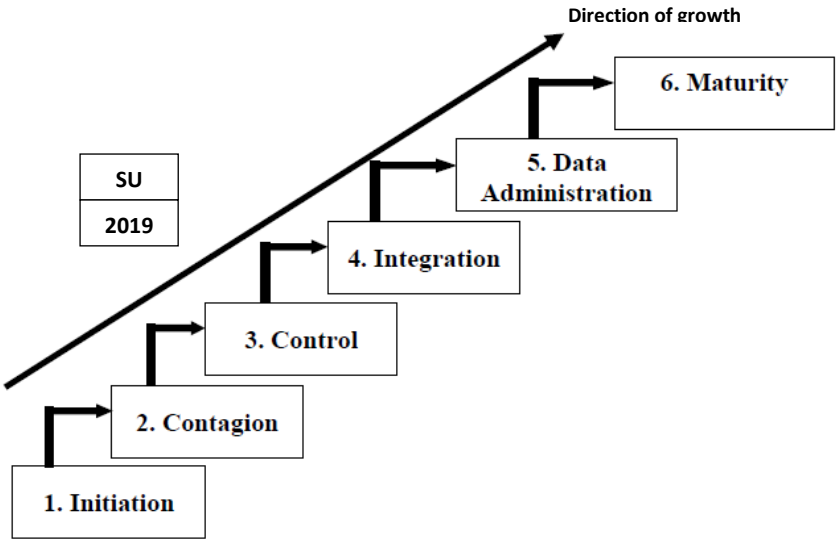


Figure 34: An assessment of the development of IS implementation at SU based on Nolan's model

7.4.3. STEP 3: Assessment of IS Implementation at SU in Business Activities on the Basis of Zuboff's Model

Figure 35 presents a general assessment of the adoption of IS systems in SU based on Zuboff's model. In general, most business activities are supported by an IS which gathers

information for reports supplied to senior management. Although these reports generally require moving data from ISs to MS Office, the information provided is reliable and used to support decisions. Also, student affairs are the only core business activity that is facilitated by an advanced IS. However, there is a need to enhance this IS to fully "Transformate" educational services. Online registration systems, as well as an e-learning system, should also be implemented. Both research activities and other business activities are still at a stage that does not meet the "Transformating" criterion that all areas of activities are supported electronically.

Business Activities	**Automate** measure technical aspects of IT (rate of information flow, accuracy, timeliness)	**Informate** IT reports and project implementation	**Transformate** perceivable improvements in service, intangible benefits (trust, loyalty, brand, etc)
The implementation of educational activities and administrative support for the education process	The purchased applications (supported by MS Office) at SU serve student management, such as course registration. Other activities are accomplished manually in many parts of SU.	Reports are only available for those educational activities supported by ISs. These reports are accurate, although they need a lot of time to be prepared as they are prepared manually after transferring data to MS Office.	
The implementation of research activities and administrative support for the research process	There is a lack of any IS for research activities at SU. This work is done either manually or through the use of MS Office.	Partial, and in most cases unreliable, information is obtainable from reports generated by MS Office.	
The implementation of other business activities, such as IS for HR management, sales, finance or documentation	There are no ISs for other business activities at SU. Such work is done either manually or through the use of MS Office.	Unreliable information is obtainable from reports generated by MS Office.	

Figure 35: An assessment of the ISs implemented at SU on the basis of Zuboff's Model

7.4.4. STEP 4: Detailed Assessment of IS Implementation at MU Using System Profiling and Process Mapping

Again, there are three main categories of ISs at SU, which is very similar to the situation at UOT and MU, namely: in-house applications, purchased suites, and stand-alone office automation packages (MS applications, AutoCAD). The number of systems used is lower than at UOT and they were mostly developed locally by a third party (commercial applications) using PHP and Delphi. This is similar to MU, but duplicated systems are not seen at SU.

In particular, Figure 36 presents (1) the process mapping for educational activities and administrative support for the education process at SU, together with an assessment of the system supporting each process. SU has a single system supporting most of its educational

activities in a form of offline system. The state of these systems is the same across all faculties. The implemented copies of this system are not integrated. There is no functional online system for SIS. No system is rated as “V”, which indicates that the system is no longer functional. However, there are no virtual libraries or e-learning program. Both laboratories and Postgraduate Student affairs are handled with the support of MS Office without an IS.

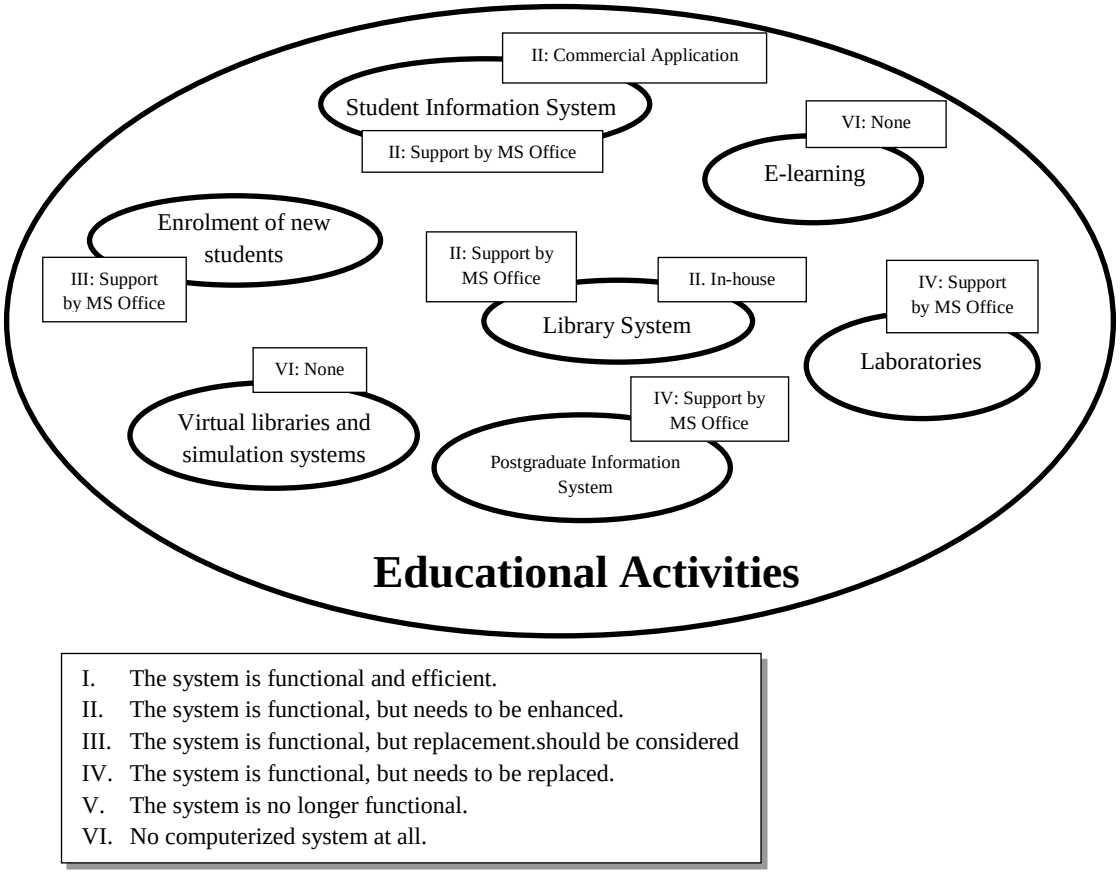
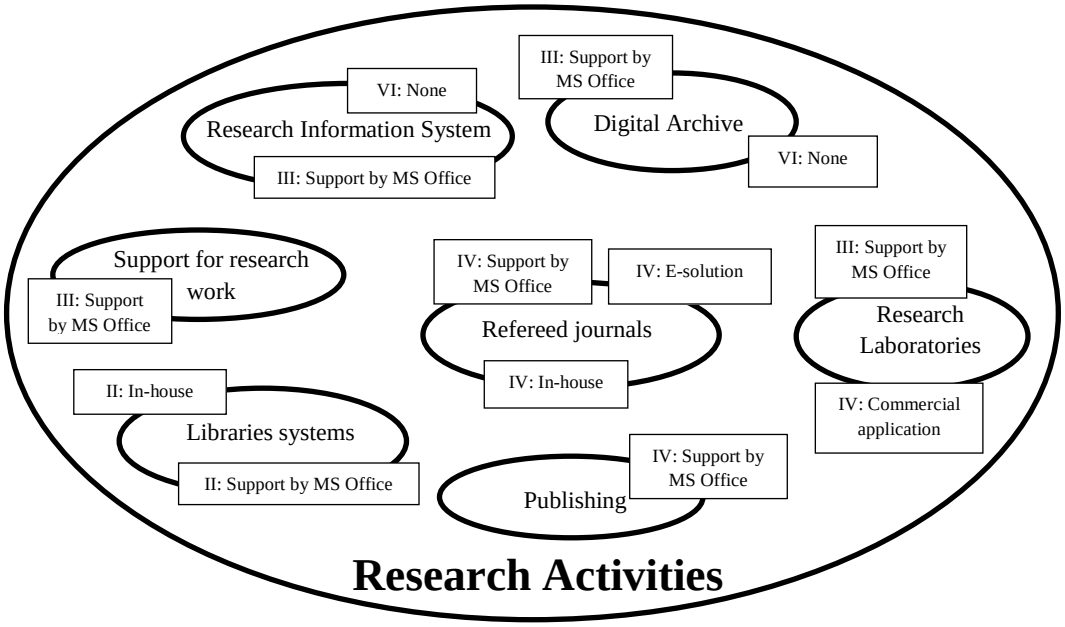


Figure 36: Process mapping for educational activities and administrative support for the education process at SU

(2) Research activities and administrative support for the research process: SU lacks any kind of RIS, including a digital archive, as is the situation at both MU and UOT. There is no system supporting the four journals or the two regular conferences organized by SU. All of them use the university website for announcements and e-mail and mail services to enable contact. The only system rated as “II” is the libraries system that was developed locally by SU. This reflects the weak status of IS support for research activities and administrative support for the research process at SU. Figure 37 presents the process mapping for research activities and administrative support for the research process at SU together with an assessment of the system supporting each process.



I. The system is functional and effective.
II. The system is functional, but needs to be enhanced.
III. The system is functional, but replacement should be considered.
IV. The system is functional, but needs to be replaced.
V. The system is no longer functional.
VI. No computerized system at all.

Figure 37: Process mapping or research activities and administrative support for the research process at SU

(3) Other processes: unlike UOT and MU, other kinds of business activities (rather than educational or research ones) have received very little support from ISs. Indeed, there is no such system rated "I" or "II". No such IS was either developed locally or purchased. In fact, such business activities are accomplished with the support of MS Office and most of them are rated "III", which indicates that the system might need to be replaced. Figure 38 represents the process mapping for other business activities at SU together with an assessment of the system supporting each process.

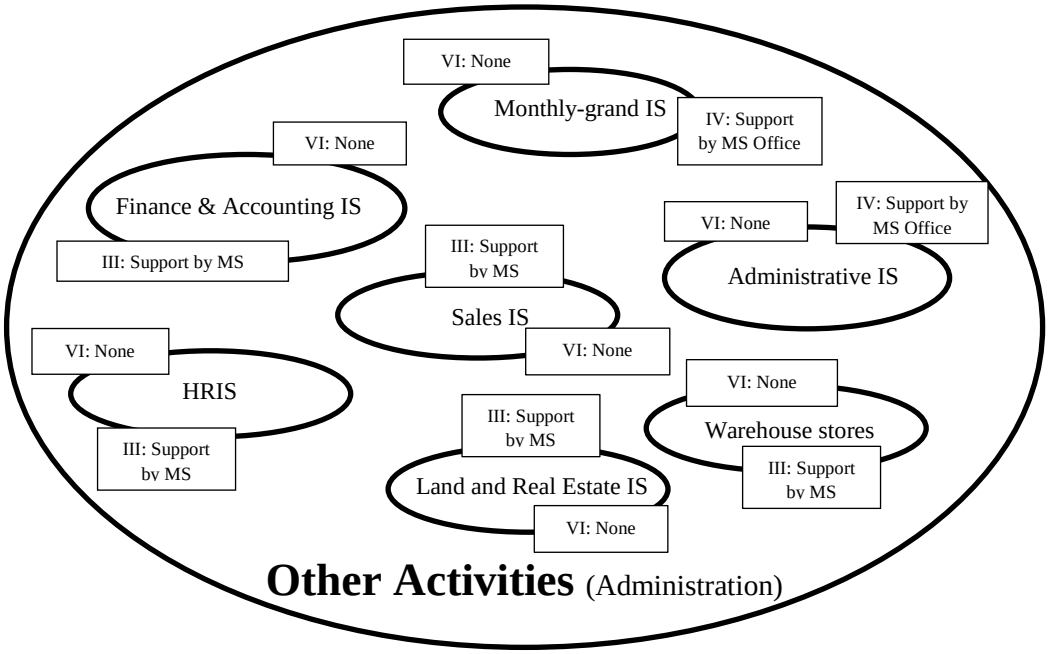


Figure 38: Process mapping for other activities (other administrative processes) at SU

7.4.5. STEP 5: Assessment of Online ISs at MU on the Basis of the CPIT Model

Basic Internet technologies are found at all levels of large organizations, which is also the situation in SU. A good example is the use of e-mail services. A number of e-mail services have been created for university staff, students and faculty administrations. Stakeholders in SU are contactable through these services. Moreover, information on educational activities is obtainable on SU's websites, such as the official SU website, although there is no online portal for students. Furthermore, there is no online interaction in educational activities for either under- or postgraduate programs. An assessment of the e-solutions adopted for educational activities at SU is presented in Figure 39.

Educational activities and administrative support for the education process are partially online	Information on educational activities is partially available online		
√	√	×	×
CONNECT	**PUBLISH**	**INTERACT**	**TRANSFORM**

Figure 39: Assessment of the adoption of e-solutions for educational activities at SU

Secondly, research activities and administrative support for such activities are based on partially online technology. Information on research activities and its administrative support are not fully available online. Limited information on the journals published by SU are available as static content on the university website. This interaction is limited to exchanging emails with the two journals, rather than installed functions in an online system. However, research activities and the administrative support of such activities cannot be considered to have even reached the "Interact" stage. Figure 40 summarizes the assessment of the adoption of e-solutions in research activities at SU.

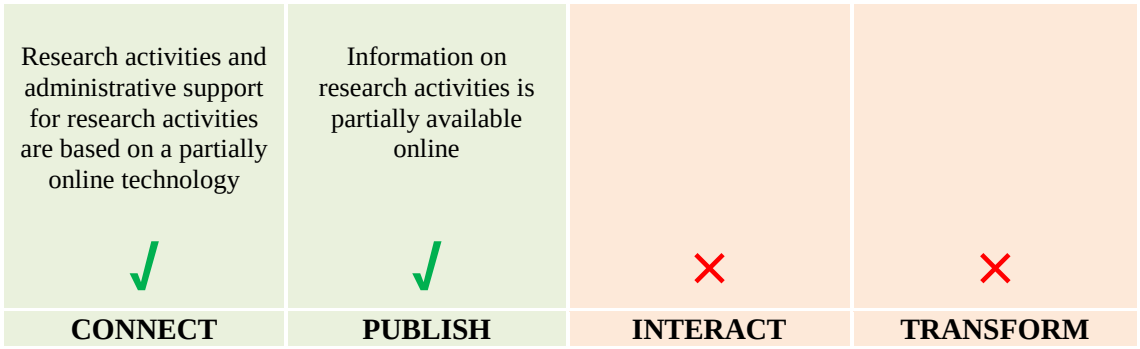


Figure 40: Assessment of the adoption of e-solutions in research activities at SU

Thirdly, the implementations of e-solutions for other business activities at SU have not even achieved the "Publish" status in most of these activities. Announcements and advertisements regarding other business activities are only available on the SU website via the use of e-mail services. Figure 41 summarizes the assessment of the adoption of e-solutions in other business activities at SU.

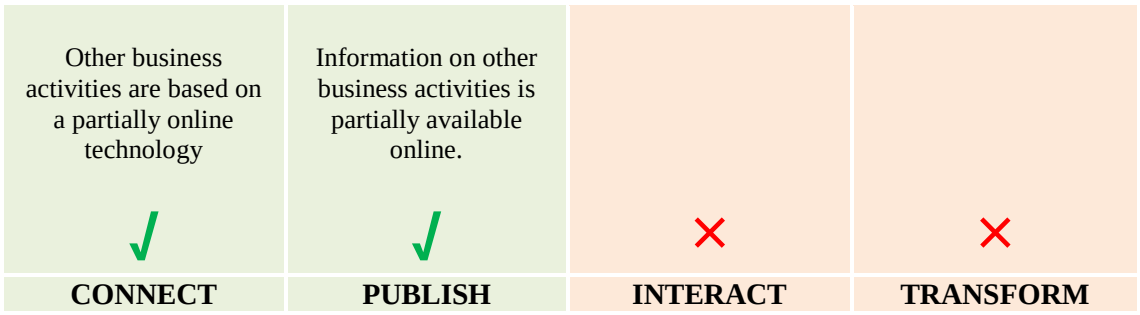


Figure 41: Assessment of the adoption of e-solutions in other business activities at SU

The SIS is seen to be the most advanced system at SU. However, there is a complete lack of e-solutions for the financial affairs system. Also, none of the fields of business activities possesses an interactive system, as represented by the "INTERACT" aspect in the CPIT model. Figure 42 illustrates the overall assessment of the adoption of e-solutions at SU on the basis of the CPIT Model.

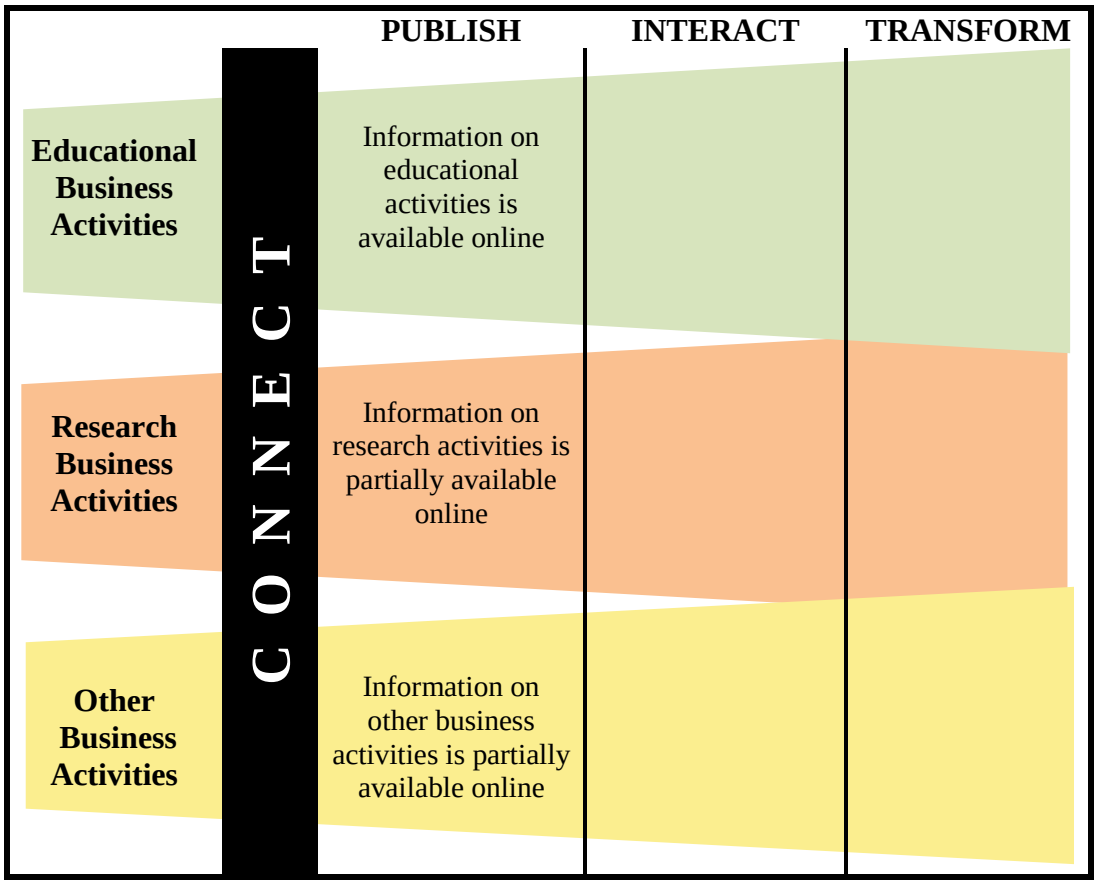


Figure 42: The overall assessment of the adoption of e-solutions at SU on the basis of the CPIT Model

7.5. Summary

In this chapter, the author has analyzed the findings from the fieldwork in Libya, which involved three universities, assessing the levels of ISs using interviews with local experts and documentation on the basis of selected techniques and models, namely: system profiling and process mapping of ISs, Nolan's model, Zuboff's model, and the CPIT model. These techniques and models have given a comparative view of the current level of ISs implemented in these three universities. Also, these studies have helped determine the level of ISs implemented and where opportunities exist for progress at the level of individual processes. In general, UOT exhibits the highest level of IS implementation among the three universities, both online and offline. The effort made by UOT is relatively uniform over all kinds of business activities (educational, research and other activities). However, treating ordinary ISs and e-solutions separately has indicated different levels of development across these universities. Indeed, MU has implemented more advanced offline ISs for other business activities. A number of lessons have been discussed. The following chapter concludes this research with an analysis of the study questions and proposes a CD-ERP model, as well as describing its limitations and directions for future work.

CHAPTER EIGHT: CONCLUSIONS AND FUTURE WORK

8.1. Introduction

The previous chapters have presented the research problem and the methodology used. Three main sources of data have been investigated, namely: relevant literature, international experiences of using a similar approach and the findings from fieldwork in Libya. This chapter concludes the study with a presentation of the research's main findings. Firstly, answers to the research questions are provided based on an analysis of the findings. Moreover, the proposed approach to the future development of ISs in the Libyan university system, the CD-ERP approach is presented which contains: a model for collaboration, a structure for the consortium, a proposal for the Cloud architecture and related recommendations. Furthermore, the study's contribution to knowledge is presented. In addition, the limitations of the study are discussed. Finally, directions for future research are suggested.

8.2. Analysis of the Study Findings on the Basis of the Research Questions

The main aims of this study were 1) to investigate the current state of the ISs implemented in Libyan universities and the potential within universities to develop these systems (see Chapters 6 & 7); and 2) to investigate approaches to system development and their strengths and weaknesses in the context of LHE (see Chapters 2 & 4). The ultimate goal was to propose a nationwide approach to implementing a modern, effective integrated system supporting all of a university's activities. The author, thus, proposes a new approach, called CD-ERP, to be applied in LHE using Libyan universities as a model. In order to check the applicability of this approach, research questions were formulated earlier (see Section 1.3). In this context, the author sought answers to these questions using three case studies involving Libyan public universities, the lessons learnt from international projects applying similar models, as well as the observations from a literature review. Based on the research presented in the previous chapters of this thesis, the followings sections discuss the study findings on the basis of the research questions.

8.2.1. QUESTION I: What Similarities and Differences Exist among System Development Approaches?

To answer this question, a comparison of system development approaches is conducted via the review of relevant literature that was presented in *Chapter Two: Conceptual Framework*, as well as the observations from *Chapter Four: International Experiences*. In general, this research considers introducing a new approach for system development in LHE, using Libyan universities as a model. This approach is jointly based on ERP and collaborative development (also known as community-source). To thoroughly investigate this question, the author seeks to answer the following sub-questions:

1) What are the benefits and drawbacks of the CD-ERP approach and non-ERP approaches in the context of LHE? If Libyan universities choose an ERP approach rather than a non-CD-ERP approach, what are the risks and consequences?

This sub-question deals with "what kind of system is suitable to the Libyan context", whether it is ERP based or not. Compared to following a non-CD-ERP approach, there are benefits and risks associated with Libyan universities following an ERP-based system. In answering this sub-question, the author analyzes the benefits and drawbacks of ERP-based systems implemented in a HE environment.

The answer to this sub-question can be found in *Section 2.3*. Most of the benefits of ERP in the HE environment are similar to the ones reported for other disciplines, including: improved access to information for planning and managing an institution, improved services for faculty, students and staff, lower levels of business risk, increased income and lower expenses, due to improved efficiency (Seo, 2013). Also, ERP has best practice, the most efficient and effective ways to realize business processes, built right into it. This results in better decision-making (Stair & Reynolds, 2010) (Rainer & Cegielski, 2011) (O'Brien & Marakas, 2011).

In particular, Zornada and Velkavrh argued that integrating all of the business functions in HE could be a significant key to implementing ERP in such an environment. Such integration requires compatible systems for student administration, human resource management systems, financial systems, and other operations that used to be supported by separate and often incompatible legacy systems (Zornada & Velkavrh, 2005)**.** These non-integrated legacy systems led to duplicating resources and services (Seo, 2013). Indeed, the implementation of an integrated database, shared by different departments, and thus of different business modules within a single integrated IS solution is of key importance. Using such an integrated IS solution, data will be transferred between departments instantly. Advanced technology, such as web technologies, mobile phones, online solutions, etc. can also be used (Zornada & Velkavrh, 2005)**.** The central repository where data are stored can give universities easy and up-to-date access to users, not only to the administrative sections within an organization, but to people who constantly interact with the organization, such as faculty, students, and staff (Seo, 2013).

Concerning the drawbacks of ERP, the implementation of ERP systems in HE and its institutes is often described as extremely difficult (Abugabah & Sanzogni, 2010). The high cost of ERP, the difficulties of its planning, implementation, customization, and configuration are the main reasons for the unsuccessful implementation of ERP, not just in the HE environment but also in other fields, In fact, there are two approaches to implementing ERP systems in an organization: BPR (Business Processes Reengineering) or ERP Customization (Seo, 2013). The latter is complex in the case of heavy customization when it comes to updating the original source code

of the ERP package. This problem may be solved by customizing only a small number of units or installing what is known as Vanilla ERP. Also, the CD-ERP model is based on an architecture involving multi-tenancy software. Multi-tenancy allows customizing code during run-time. This means that the updating of ERP packages can run smoothly. BPR is usually avoided, since it generally requires restructuring the organization, which is considered to be a complex and risky task, especially in a unique environment such as HE.

Rani claimed that the difficulties in implementing ERP are relatively prominent in HE institutes, since they form part of the non-profit sector and are supported by governments, especially public universities (Rani, 2016). The unique characteristics of HE interfere with the implementation of ERP. Indeed, the term "*commercializing higher education*", which means "treating education as a business and students as customers", could make the resistance to implementing ERP in universities much greater, because it involves not merely the adoption of a new IS, but a holistic change in the organizational culture (Pollock & Cornford, 2005).

However, almost all of the studies conducted on the implementation of ERP have shown that ERP software itself is rarely the source of failure (Noaman & Ahmed, 2015). This is confirmed by studies, such as (Scott & Vessey, 2000; Helo et al., 2008; Maditinos, Chatzoudes & Tsairidis, 2012) in which it is reported that the failure of the implementation of ERP was not caused by the ERP software itself, but rather by the complexity of the massive changes caused by the implementation of ERP in organizations (Seo, 2013). Helo et al. explained that ERP systems are not like other ISs in terms of the problems involved in implementation. These problems are often not technical issues, such as technical complexity, compatibility or standardization, but rather organizational and human-related issues. They provide some examples of such organizational and human-related problems, including: resistance to change, organizational culture, incompatible business processes, project mismanagement, and lack of commitment from top management (Helo, et al., 2008) (Seo, 2013). Zornada and Velkavrh argued that these failures can be explained by the fact that the implementation of ERP has forced organizations to follow the principle of 'best-practice', as seen in the most successful organizations, and from appropriate reference models (Zornada & Velkavrh, 2005).

Considering the potential benefits of ERP under this model, Seo notes that public universities are under pressure from both the government and the public, specifically in the form of decreasing government funding and increasing expectations from stakeholders. For these reasons, ERP systems might be very appealing to HE institutes as a potential route to meeting the criteria for achieving greater integration in their management systems (Seo, 2013). Abbas added that the role of top management is critical to handling the reengineering of business processes in universities. Such environments are very rigid and resistant to change. Hence, top

management should ensure that employees are informed and involved in the implementation process and progress (Abbas, 2011). Abbas's study confirmed what was stated by Al-Sehali ten years before. According to a literature review by Al-Sehali, the support of top management was one of the factors most frequently stated as being critical to the success of ERP implementation (Al-Sehali, 2000)**.** Another argument is that overrunning the deadline for implementation could be seen as a benefit in HE, rather than an issue. Fisher ran a study to examine the perceptions of staff regarding the implementation of ERP in three Australian universities. This study indicates that overrunning the deadline for implementation is associated with a more positive perception of ERP. Unlike in other fields, in HE such delays may be perceived as giving more time for additional training and relieving the pressure on the staff using the new system (Fisher, 2006). Besides, it is noticeable that the failure rate in HE is at the lowest rate among various sectors, as mentioned in Section 2.3.6. Indeed, some of the studies showed that 50% of the implementations of ERP in HE institutes went over their budgets and did not meet the scheduled deadline (Abugabah & Sanzogni, 2010). This is generally consistent with failure rates in other sectors where different failure rates in ERP projects are often reported ranging between 50% and 70% (Saxena & McDonagh, 2019).

Based on the summary of factors of the failure of ERP given in Section 2.3.5, 28 out of the 34 factors of failure are related to managerial aspects[1]. Also, none of the technical factors listed, apart from the one given by (Rani, 2016), "*ERP are difficult to learn and use, with a complicated user interface*", are directly related to ERP systems themselves. This confirms that ERP software itself is not a major cause of unsuccessful implementation.

Also, more supporting evidence can be found in *Chapter Four: International Experiences – Section 4.2.4:* Although ERP packages are becoming an essential component in today's world, many of the systems generated by community-source projects are difficult to integrate with ERP packages. Also, building a system on existing code that works at least fairly well, as was the case for Sakai and Kuali, is a successful approach. Such an approach negates the need for hard negotiations about basic decisions regarding the architecture of a system. It also increases the likelihood that a project can achieve rapid success and so prove its potential value (Courant & Griffiths, 2006). These observations support the CD-ERP model, which is based on ERP and projected to achieve early success and thus build momentum. Also, the case studies presented here[2] have shown that Libyan universities need a radical move to

[1] For more details, refer to Table 3: Summary of factors leading to unsuccessful ERP implementation.
[2] Please refer to Chapter Six: Case Studies and Findings and Chapter Seven: Analysis and Discussion. For a summary, and Section 8.2.3 will present the main issues with regard to the assessment of the ISs implemented in Libyan public universities.

enhance their systems or, in most cases, to even completely rebuild them, as the current level of the ISs implemented is very low. Building systems from scratch is costly in terms of time and budget. Consequently, Libyan universities or LHE institutes in general, may not have many options for adopting a fairly well-functioning platform to start with, while in return, ERP offers a promising and alternative solution.

2) What benefits can be gained and what difficulties are expected using a collaborative-development approach compared to the approach of separate projects carried out by individual universities?

This sub-question is seeking the answer to "how should the system be developed?" should Libyan universities follow a collaborative model or work separately. The observations in both *Chapter Two: Conceptual Framework,* and *Chapter Four: International Experiences* indicate the answer to this sub-question. Firstly, the answer to this question is partially found in *Chapter Two: Conceptual Framework –Section 2.5*. The collaborative development approach was first proposed by Brad Wheeler and defined as a type of open source project that is governed by a group of educational institutions or firms (Wheeler & Hilton, 2012). In the community-source environment, a consortium of partners shares their financial efforts and human resources to complete a project. This project is managed using a typical model of consortium governance (Hanganu, 2008).

In fact, using a non-collaborative approach, the development of ISs faces a variety of challen ges, such as: developers working alone without knowledge sharing; work not being checked by other developers; if one of the developers leaves, nobody may know how a piece of software works and it might be difficult to revert to a previous version of the code. Currently, working in geographically dispersed groups has become common practice for IS projects. The CD-ERP model proposes a consortium of Libyan public universities, to jointly develop their ISs. It is projected to achieve greater revenue, enable higher productivity and quality at a lower cost and to create a pool of nationally available skilled resources (Shrivastava & Date, 2010).

On the other hand, the geographical distribution may cause additional difficulties to those of the development issues regarding traditional ISs. In a distributed environment, challenges tend to be emphasized and other difficulties can arise due to physical and temporal constraints (Rocha, et al., 2011) (Hyysalo, 2014) (Lanubile, 2009). As stated, many of the challenges that arise in practice can be traced back to the dimensions of communication, coordination, control, development, and maintenance. The geographical dispersion of team members (located in Libyan universities) and, in some cases, time-zone differences (in the case of ERP vendors) must be taken into consideration (Sengupta, et al., 2006). Various organizations face a wide range of difficulties due to the geographical separation of developers. Time

and cultural differences, together with geographical distance, are the main causes of such problems (Shrivastava & Date, 2010). For more details on these issues, Table 5 provides a summary of CSFs for collaboration in IS development.

Another supporting answer to this question can be found in *Chapter Four: International Experiences:* in which community-source has been adopted by many universities and government bodies worldwide, despite its difficulties. Traditionally, HE is a sector based on knowledge sharing. From this point of view, community-source is considered as a means of knowledge sharing alongside other such means of cooperation, such as sharing costs or human resources. As a result, community-source was described as a "perfect fit" to the philosophy and standards of research and education. Moreover, based on the cases mentioned in *Section 4.3.1*, it is clear that developing open source applications collaboratively can give results which meet the needs of the participating institutions, as well as give the potential for greater benefit to the broader community, especially when we see that some cases in the HE sector have a fairly robust tradition of building their own software, such as Kuali or CINECA. Besides, community-source is projected to overcome the historically encountered gap between software producers and the HE sector. Indeed, the HE sector is considered to be a unique environment with complex and poorly understood requirements, as the author has noted previously several times.

More supporting evidence for this conclusion may also be found in *Chapter Seven: Analysis and Discussion*, in which S-2 was asked about "the possibility of implementing purchased open-source software" and replied that "I can see them as a better solution, especially if other local universities cooperated in such a project"[1]. This interviewee was working as the head of the Programming and System Analysis Office in the ITDC at SU. He continued to express his opinion on the possibility of sharing resources (human and budget) among Libyan public universities to build in-house applications, purchase open-source suites or at least to guide development in the case of outsourcing the project to a third party.

Another term used in the proposed model is "Cloud Computing" (CC) that can be found in *Chapter Two: Conceptual Framework – Section 2.8.3*. CC is included in the CD-ERP model since it represents a great benefit to HE, especially when universities intend to work jointly. The growing interest in CC within the HE sector could be the result of many factors, such as the availability of a modern learning environment where students want access to education at any time and from anywhere. Also, users in the HE sector use a variety of devices to access information and thus web-based services are needed. All of these features can be provided in a CC environment with possibly no need to increase the budget (Kiryakova, 2017).

[1] See Table 30 for S-2's responses. M-2 agreed to this opinion to some degree (see Table 29).

Although there exist challenges to CC, such as the security matters discussed in Section 2.8.3, there are many reasons for HEIs to use CC. In fact, there is no failsafe means of ensuring security or data protection in any system. HEIs have to overcome their fears. Furthermore, as CC already has a relatively long history, there are well-known service providers, and practices and models for transitioning to CC, which helps minimize risks and creates conditions for efficient and secure activities in the Cloud. Some risks associated with CC could alternatively be viewed as benefits, such as: storing data and applications in CC will preserve them in the case of a disaster. Also, due to the high level of protection in CC, data and applications are often better protected than on companies` local servers (Kiryakova, 2017).

As a result, developing a Cloud architecture for HEIs can be challenging and must take into consideration the purpose and infrastructure of the institutions themselves, together with national rules and regulations (Mathew, 2012). Indeed, the implementation of CC in HEI faces many challenges, which may vary from technological aspects to national rules and regulations. After the HEIs have established where their data will reside and defined a protocol for data security, an agreement, also called an SLA (service level agreement), can be made with a Cloud service provider (Mathew, 2012). It is very important to determine the nature of the interaction between the CC providers and the HEIs based on such SLAs. Particularly careful selection of CC providers and data deployment is needed, "especially in the case of public clouds" (Kiryakova, 2017). Also, following a life cycle is recommended, in which a "step-by-step transition" to CC helps HEIs overcome certain risks. HEIs can benefit from various models of deployment (public, private, hybrid or community Cloud), as well as different models of service (Infrastructure as a Service, Platform as a Service and Software as a Service) (Kiryakova, 2017).

As mentioned in *Chapter Two: Conceptual Framework – Section 2.9*, we can see the powerful capability offered by multi-tenancy that is included in the CD-ERP model. Multi-tenancy allows a variety of organizations to securely, and in common, use one application to reduce costs and increase operational efficiency, while various degrees of isolation or sharing could be implemented. There are several reasons why multi-tenancy architecture is part of this model. First of all, the challenges of adopting a multi-tenancy architecture, such as security, regulations or scalability, are most visible when completely different organizations cooperate in one project. In the context of this research, Libyan universities are organizations that share common characteristics and, in particular, are geographically clustered. Also, a central organization (the Libyan Ministry of Education) delivers some common services to multiple IT sub-departments (of Libyan public universities) that also have autonomous service delivery portfolios. It seems natural that these universities would benefit by sharing the costs of management, as well as of infrastructural and application development, by adopting a multi-tenancy architecture. Also, in cases

where a university requires a customized user interface with a unique brand or logo, multi-tenant applications are configurable in this way. However, there are a number of issues that must be considered before adopting a multi-tenancy software architecture, as explained in Table 8.

8.2.2. QUESTION II: How Successful have other International projects been and What can be learnt from their experiences?

To answer this question, the author will refer to the description of the cases of international projects following a similar approach that can found in *Chapter Four: International Experiences*. Consortiums of universities have existed for a long time, such as the CINECA project in Italy which dates back to 1969, while the community-source paradigm was first applied by the KUALI and SAKAI projects in the United States. Other similar projects have been deployed in a variety of countries worldwide. Many of the problems observed in these projects are similar to those that have already been described by the author in the literature review contained in Chapter Two, especially in regards to distributed and collaborative working environments, including:

- Generally, community-source projects (which create a distributed environment by their nature) are more challenging than non-distributed projects (Hubner, et al., 2008).
- The challenges and complexity of joint development result from the diverse requirements of various partners (Liu, et al., 2014).
- The issue of the governance model and the ownership of code (Courant & Griffiths, 2006).
- The issue of project management becomes a critical issue in successfully developing a system using a community-source approach (Liu & Qiang, 2011).
- The costs of coordination and communication across multiple regulatory partners within and across projects increases as the number of members increases and projects develop (Liu, et al., 2015).
- Knowledge management is crucial in such projects (Hanganu, 2008).
- A certain level of face-to-face communication in working situations is essential, which could be difficult in some cases (Hanganu, 2008).
- Security concerns (Liu, et al., 2014).

Furthermore, the analysis of international projects has led to other observations, as follows:

- Community-source is an environment where each partner must view other partners as non-competing, to share some of the costs, risks, and potential rewards (Wheeler & Hilton, 2012).

- As a natural part of the life cycle of collaboration, a change in goals or vision among the members of a community can lower the level of cooperation, or in some cases even terminate a project. Some authors consider community-source to be a transitional phase rather than a lasting model. As one example of this, Sakai moved towards open-source development and joined the Apereo Foundation in 2012, while Kuali exhibits a similar history.
- Building a system on existing code that works at least fairly well, as was the case for Sakai and Kuali, is a successful approach. Such an approach negates the need for hard negotiations about basic decisions regarding the architecture of a system, as well as increasing the likelihood that a project can achieve rapid success to prove its potential value (Courant & Griffiths, 2006). This supports the proposed approach, which is based on ERP and projected to achieve early success and thus build momentum. A consortium of Libyan universities is expected to get fast and reliable results, as they will not start coding from scratch, especially as the fieldwork in Libya has shown a low-level of IS implementation as it is highlighted later in *Section 8.2.3*.
- It is challenging to integrate some projects (for example, Sakai) with other enterprise software systems, such as ERP (Monarch, 2010). This is another reason why this approach is based on ERP, in addition to avoiding the reconstruction of systems from scratch.
- To guarantee that development does not slow down too much, a core team of selected partners should be created (Hubner, et al., 2008). Having a large number of partners developing a system might affect the development process negatively since these partners might have diverse needs and communication costs increase (Courant & Griffiths, 2006). Hence, it is probably better to create a team from a small number of selected partners (e.g. the leading universities in each province) to develop the core systems (or at least guide their development), without neglecting other partners' requirements. The possibility of customization exists to fulfill such needs.
- When adopting a collaborative development approach, the structure of the consortium should be considered carefully. As mentioned before, HE institutes are unique and their needs are not well understood. Hence, collaboration with a group of such institutes is complex (this provides an interesting topic for future research). Accordingly, the structure of some of the international projects has been adapted or incorporated into the proposed model presented at the end of this thesis.
- Closed community source is the preferred way of development in some of these cases since it possesses the benefits of both commercial and open-source software. Indeed, the rights to the ISs developed in an open-source project are granted exclusively to its members.

- Finally, little attention has been paid to the community-source approach in the literature, as few relevant and reliable sources are available. Hence, more research should be carried out in the future to cover all aspects of the community-source approach.

8.2.3. QUESTION III: How does IS Implementation in Libyan Universities Look in the XXI Century after Years of Serious Technical, Economic and Social Development?

To answer this question, an in-depth analysis of the ISs implemented in case studies has been conducted using the assessment framework. This assessment also considered whether or not Libyan universities are capable of building and implementing an administrative system (in-house applications). The answer to this question is found in *Chapter Seven: Analysis and Discussion– Sections 7.2, 7.3, and 7.4*, in which the assessment framework works as an instrument to evaluate the ISs implemented in Libyan universities, through the responses of IT experts about their assessment of the current level of the ISs implemented at their university. Besides, a number of techniques and models have also been used in the assessment framework to answer this question, namely: analysis of the overall level of ISs on the basis of Nolan's model, analysis of the ISs implemented on the basis of Zuboff's model at the level of business activities, system profiling and process mapping of ISs to assess the ISs implemented for sub-business activities, and finally the analysis of the level of e-solutions on the basis of the CPIT model.

Through the evaluation, the author noticed that all of the three universities studied share common characteristics, as well as differences, in terms of the status of the ISs implemented, which are summarized as follows:

- Generally, the level of technology in Libya is low, which should be considered before adopting advanced systems.
- The low-level of ISs implemented in all cases, as well as the lack of capabilities for system development.
- More qualified staff are required, which is not possible within the unique environment of universities. The current development teams are unable to troubleshoot all of the systems currently running, which is reflected in the limited expectations regarding the results from using these systems. This problem should be relieved by adapting a CD-ERP model, since universities participating in the consortium would share their human resources.
- In all these three universities, there are three main categories of ISs used, as itemized below:
    - In-house applications developed locally by their IT teams. All of these applications are out-of-date, not well documented and possess many problematic issues. Besides, these applications have been developed using a

variety of technologies and are run on several different platforms, which makes it impossible to integrate them into a single connected architecture.
    - Applications were purchased from local vendors and are mostly maintained by the vendor itself. In some cases, there are open-source applications that can be modified by the local IT team. However, these applications are not easy to maintain or develop. As above, these purchased applications cannot be integrated into a single connected architecture. However, this situation is even worse, since some of these applications are not editable.
    - Standalone office automation packages (MS Excel/Access) are used to support most types of business activity in all three universities. The use of such applications is widespread across these universities. In some cases, these applications are used alongside ISs.
    - Integration between these systems is limited to manual communication. There is no bridging software at all. Data are transferred in a format such as Excel, CSV, database files or even re-entered manually in some cases. Such data transfer can be risky.
- Although top management appears not to be satisfied with the existing ISs, it is not quite ready to invest more in IT. Top management is convinced that most business and sub-business activities need applications based on the latest technology, but is worried about the subsequent costs.
- There has been a noticeable improvement in the reliability of information gathered in business activities due to the use of ISs, which is reflected in better decision-making. This improvement is limited, since the reports generated from the ISs are not available instantly, as required by top management. Most of them are transferred in paper format or by converting them into other files, such as MS Excel or Access.
- Paperwork using application forms is still being applied prior to data entry in most of the systems mentioned in the case studies.
- UOT showed the highest level of IS implementation (both online and offline) among the three universities. The level of effort made by UOT in the three kinds of business activities (educational activities, research activities, and other activities) is relatively uniform, although only the ISs implemented for educational activities have been transformed into a fully-integrated system. This is confirmed by a comparison of the level of development of ISs in these three universities using Nolan's model (see Figure 43). In fact, UOT is the only university that has passed through the control stage. Indeed, serious actions have been taken towards integrating all of the systems implemented in UOT, which cannot be seen in the other two universities.

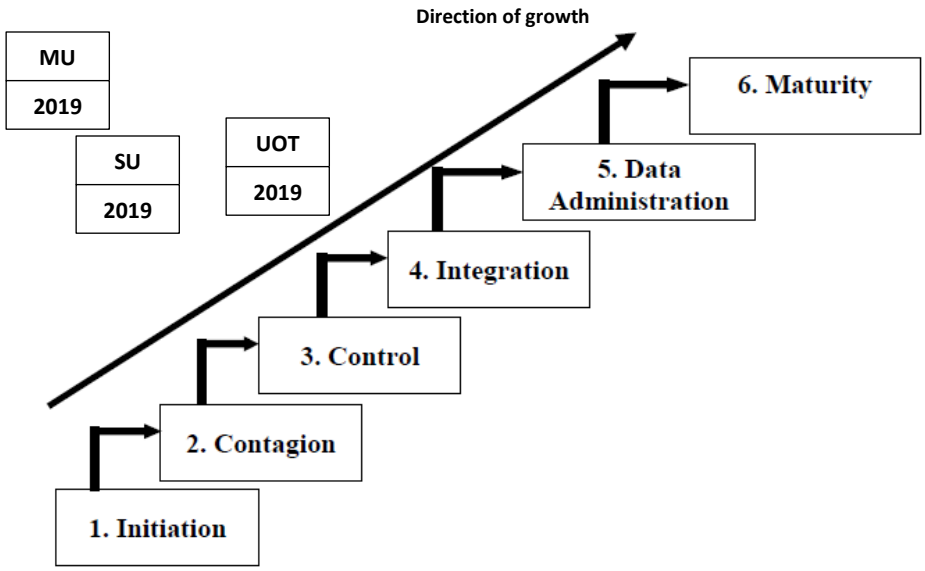


Figure 43: Overall analysis of IS growth in all cases based on Nolan's model

- MU has developed more ISs for other (non-teaching and non-research) activities, such as financial affairs, real estate and Global Positioning System (GPS), sales, and warehousing.
- SU has the lowest number of ISs implemented among the three universities.
- In all three universities, the observations showed a very low-level of ISs for the implementation of research activities and administrative support for the research process.
- The issues of duplicated systems are seen in both UOT and MU, especially in the SIS, while SU does not experience such an issue. As stated by S-2, this is the situation in all Libyan public universities, except for SU and University of Benghazi (see Section 7.4.1). This could be a result of the fact that SU is a relatively newly established university compared to the other two. Also, the modern technologies that appeared after the establishment of SU have played a vital role in continuously developing more reliable ISs.
- Cooperation in the field of IT has already been established between Libyan public universities. For example, UOT was considering the adoption of the SIS developed by the University of Benghazi before developing their current SIS by themselves. Also, Al-Mergib University and Bani Waleed University recently adopted the SIS developed by UOT. The associated contract includes the requirement that UOT trains IT staff in these two universities to use the source code, e.g. to troubleshoot the system.
- In point of fact, the considerable number of similar projects based on community-source software and collaboration in the HE sector across the world indicates the continued success of such an approach (see Chapter 5: International Experiences).

The observations from the fieldwork in Libya indicate that there exists sufficient potential in the LHE system as a whole (rather than as individual HE institutes). In particular, cooperation between Libyan universities has shown positive results (as mentioned above). Most importantly, the Libyan Ministry of Education provides all of the public universities with resources (human resources, financial funding and practical support). With such support from the ministry, a consortium of Libyan universities (or LHE institutes) can together build a sufficiently large set of skilled employees. Indeed, the Libyan Ministry of Education can work as a reliable central organization and guarantor of the central repository that delivers common services to multiple IT sub-departments (Libyan universities or HE institutes).

- Finally, the ISs in all of the Libyan cases are based on relatively low-level technology and there is a lack of capability for system development within individual universities. It is suggested that the CD-ERP approach is suitable in the Libyan context. The international projects considered were based on existing systems that were used to jointly build integrated systems. Although the managers of these international projects note the difficulties arising from the lack of integration with ERP, they did not restructure their systems to include ERP. The leader of the USOS project in Poland stated that if there had been the chance to build the USOS project using such technology as ERP and multi-tenancy when they started the project, they would have done so. Despite this, the costs of the process of now rebuilding the system using these technologies would exceed the expected benefits.

8.2.4. QUESTION IV: What approach to IS development is best suited to the size and needs of Libyan universities, and what is the most practical method of transformation?

To answer this question, the author proposes a CD-ERP approach for LHE. This proposal includes: the proposed model of collaboration, the business model of the consortium, the consortium structure (governance model), the Cloud architecture and a number of recommendations enabling successful and efficient transformation from the current traditional system to a CD-ERP system. The following section presents the answer to this question based on the research findings and observations.

8.3. The CD-ERP Approach

8.3.1. Overview

The name of the Model: Collaboratively-Developed, Cloud-based Multi-tenant ERP systems (in short: CD-ERP)

Definition of the model: CD-ERP is a model of software development that is intermediate between two well-known models (closed and open-source systems) in which both the administration and the development costs are shared among the beneficiaries (here Libyan universities under the direction of the Libyan Ministry of Education). The CD-ERP model is a comprehensive and secure version of Cloud-based ERP whose development is jointly realized (or at least guided) by educational institutes. Such an IS provides access to current information to all of the project stakeholders on any appropriate device. Administration of the project and cost management are determined according to the rights and duties of stakeholders as defined in an agreement. The model targets both LHE institutes and the planners of the LHE at the Ministry of Education. With the adoption of cloud-based ERP solutions, different universities and colleges are projected to have all their business activities (educational, research and other activities) supported by one integrated system, as shown in Figure 44.

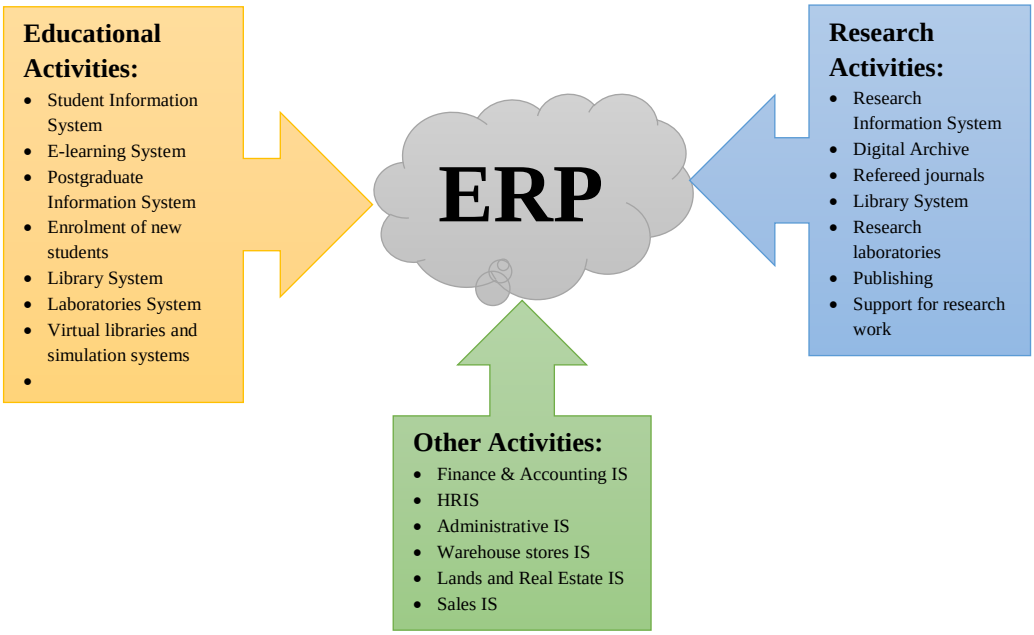


Figure 44: Cloud ERP for HEI institutes

8.3.2. The Proposed Model of Collaboration

Based on the observations and findings, we cannot say whether the proposed model should involve outsourcing or insourcing, and whether it should be onshore or offshore. In fact, the CD-ERP model is a hybrid one in which the ERP part follows an outsourcing approach, while universities collaboratively develop an IS and configure/customize open-source ERP using an onshore approach. Also, this model does not simply involve traditional forms of collaboration, but rather collaboration in developing an IS for all the beneficiaries (here Libyan HE institutes under the direction of the Libyan Ministry of

Education). The approach of collaborative development can be applied in various sectors, such as universities, governments, and private sectors.

8.3.3. Proposed Structure for the Consortium

The proposed structure is based on research observations and findings. The business model is summarized in the following points:

1) Type of consortium: a non-profit consortium of Libyan HE and research institutes, as well as the Libyan Ministry of Education (or equivalent). The consortium should provide high-performance computing services, such as hardware resources, software applications and human expertise.
2) Structure of the consortium (governance model) – as illustrated in Figure 45, the consortium consists of two main bodies, namely: the Consortium Council and Board of Executive Directors, together with other committees that may be created as required. The council of the consortium is composed of the rectors/delegates from all the Libyan HE organizations that are members of the consortium (public universities, private universities, community colleges or research centers), each with equal voting rights. The executive directors consist only of representatives from the core members. Involving all the members in every detail of the work would slow down development too much.

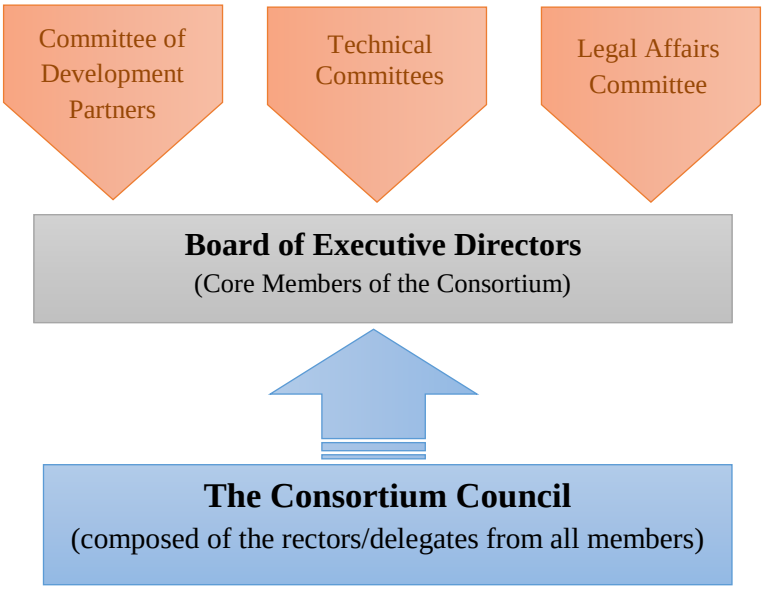


Figure 45: Structure of the Consortium (Governance Model)

The board of executive directors is responsible for the development, organization, and management of the consortium's activities. The executive directors carry out crucial tasks such as initiating projects, proposing budgets or generating reports. The final approval of these tasks is, however, the responsibility

of the consortium council. Such a structure ensures that all members have a right to be involved in the decision-making process.

Besides UOT as the main headquarters of the system, the choice of the core members could be based on the leading universities from the six main regions in Libya as follows:

- Western region: represented by UOT, located in Tripoli and MU, located in Misurata.
- Central region: represented by SU, located in Sirte.
- Eastern region: represented by University of Benghazi, located in Benghazi.
- Green Moutain region: represented by Omar Al-Mukhtar University, located in Al-Bayda.
- West-Moutain region: represented by Gharyan University located in Gharyan.
- Southern region: represented by Sabha University, located in Sabha.

Other committees could be created as required with a minimum of three permanent committees, namely: Committee of Development Partners, Technical Committee and Legal Affairs Committee. Local companies that are involved or would like to be involved in the consortium can join the Committee for Development Partners by agreement with the consortium members. In return, these companies would get priority to become engaged in consortium projects. The idea of such a committee comes from the Kuali project, where a similar approach is used, as well as the findings from the fieldwork in Libya, which indicate that all three universities host their data centers in the same local company. Another example is the technical committee, in which individual members or sub-committees may have responsibility for particular issues (e.g. development, data storage, security, networking). This committee will give expert advice to the executive directors. The Legal Affairs Committee will handle compliance with the law, the statutes of the member universities and the principles of proper management. Each committee should/may consist of or form units to handle particular assignments, for example, the development committee may form a database unit, applications unit, web development unit, or any other specified unit as needed.

3) Source of funding: The consortium is non-profit, fees collected are used to cover costs of system development. First, new members should pay a joining fee. The joining fee is compensation for all the applications received by the new members when joining the consortium. Also, there are annual fees. The annual fee is generally for the day-to-day costs of the system. Besides covering the cost of the programmers' salaries, it also covers the costs of daily maintenance, helpdesks, new features, new applications, etc. The level of both fees is based on the size of a member so that even small institutes can join the consortium. Members of the Committee for Development Partners also pay regular fees and are required to

provide IT services to the community members, in return for priority in project tenders. The level of participation of these members determines the privileges granted.

4) Features:
   - Developing the ISs needed by the members, or at least guiding their development.
   - Fully operational ISs and technical support are available to members, including all subsystems and modules. All members have rights to open-source ERP-based integrated systems. Source code is available on-demand for institutes participating in the project with no limits on internal end-users and installations. These systems are developed collaboratively, but ERP modules can be customized to meet an LHE institution's unique needs. It is advised that customization be limited to critical processes, to avoid the costs and disadvantages of heavy customization.
   - Multi-Tenancy in which customization can be carried out during run-time so that the core ERP code will not be changed. This allows the ERP vendor to upgrade their system smoothly.
   - PaaS is provided for the possibility of developing new applications.

8.3.4. Approach to Development under the CD-ERP Model

IS researchers have long argued that the architecture of a system plays a pivotal role in coordinating development work (Herbsleb & Grinte, 1999). The architecture proposed for CD-ERP is based on Conway's law in which an IS's design reflects how the organization communicates in everyday business. In this context, two elements are discussed in this section, namely: the selection of the core members and associated tasks, and the SDLC (System Development Life Cycle).

1) Strategy for Selecting the Core Members and Associated Tasks

The selection of the core members is summarized in Figure 46. Since Libya consists of six regions, the author has chosen the leading university in each region based on size and year of establishment. It is noticeable that the western region is the only region represented by two universities (UOT and MU), partially since it is the most populated region in Libya. Also, UOT is considered to be the leading university in Libya and has contributed to the establishment of other universities. UOT is located in the capital city of Tripoli, which is the most developed city in Libya and where all of the ICT companies operate. Moreover, the findings discovered that UOT showed the highest level of IS implementation (both online and offline) among the universities studied. Hence, UOT was chosen to be the

main headquarters of the system at this stage. Later, two main headquarters should be added, e.g. at Benghazi University and Sabha University[1]. Decentralization is desirable, since Libya is the fourth largest country in Africa, and is the 16th largest country in the world, thus it is impractical to have only one headquarters.

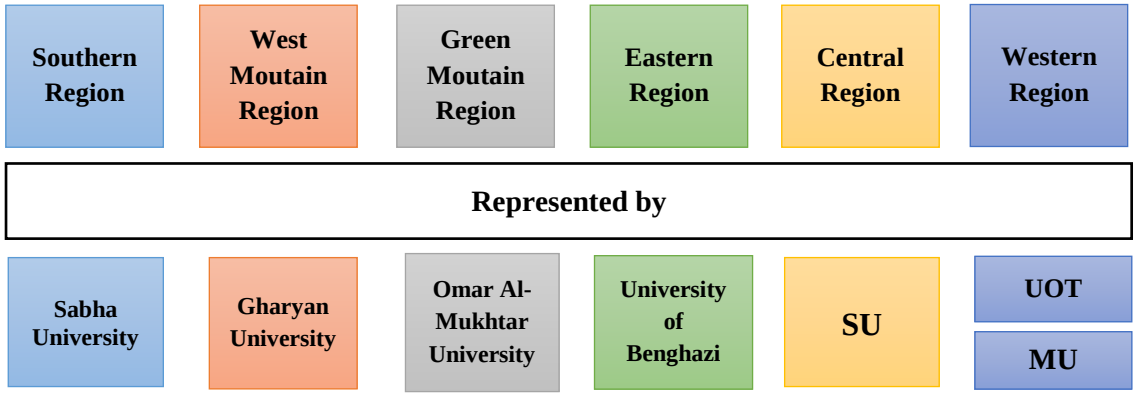


Figure 46: The core members of the consortium

Based on the observations from the literature, and the fieldwork in Libya, the major services supported by ISs include those indicated in Table 31. These services reflect a plan that 21 modules will be implemented in the integrated system to be built for LHE using the CD-ERP model.

As mentioned in Section 2.6 and Section 2.7, dividing modules to be developed entirely by different core members is expected to have drawbacks in which different locations will become over-specialized in particular components. Over time, this would build up knowledge silos leaving the team with new work that can only be done by one or two people. The proposed solution under the CD-ERP model is to assign the modules to be developed to different members in such a way that teams are split horizontally (e.g. one university is responsible for the presentation/user-interface, another for the database, and another for web-based services). The division of the modules should be roughly equal among the core members to guarantee that none of the universities becomes over specialized in particular modules. Again, these modules are classified on the basis of the model of business activities in HE institutes presented by (Zornada & Velkavrh, 2005) which has been used throughout this research. The development process in each class should be led by one major university (the leading universities located in the main cities of Libya, which are UOT, University of Benghazi and Sabha University). This will simplify coordination between the universities involved in

[1] Basically, the choice of the University of Benghazi and Sebha University, along with UOT, is based on the three historical provinces of Libya. All recent Libyan governments have used this administrative division, although there are now more provinces in Libya.

developing a particular module, as well as with the vendors of the ERP on which the system is based. These three universities are also projected to be the main headquarters of the system.

To clarify this, let us discuss the following example as illustrated in Table 31. The development of modules listed under educational activities is led by UOT. The first example shows that the module of SIS is to be developed by three members (the application/user interface by SU, the database by Gharyan University, and the web content by Sabha University). UOT is responsible for guiding and controlling the development of this module, as well as the coordination between these three universities. Similarly, other modules will be developed collaboratively by several universities, while the control of the development process is accomplished by one of the three leading universities in Libya.

Table 31: Example of dividing Modules between core-members

Activities and associated IS	Application Layer	Database	Web-based
Educational Activities (Led by UoT)			
Student Information System (SIS)	SU	Gharyan University	Sabha University
Enrolment of new students			
Learning Management Systems (LMS)			
E-learning System			
Library System			
Laboratories System			
Virtual libraries and simulation systems			
Postgraduate IS			
Research Activities (Led by University of Benghazi)			
Research IS			
Digital Archive			
System of Refereed Journals			
System of Research Laboratories			
Libraries IS			
Publishing IS			
Other Activities (Led by Sabha University)			
Monthly-grand IS			
Finance & Accounting IS			
HR IS			
Content Management System (CMS)			
Sales IS			
Warehouse stores IS			
Lands and Real-Estate IS			

2) The SDLC for the CD-ERP Model

As mentioned, the CD-ERP model describes a distributed environment which, by nature, is not suited to agility. Also, a traditional SDLC is impractical. The

author, hence, proposes a hybrid model that is based on the bimodal principle[1] in which a traditional (predictive) model and an adaptive model are combined. As illustrated in Figure 47, the planning and analysis phases (using a predictive model) are first carried out for each module. Then, each module will go through a number of sprints to deliver the final product.

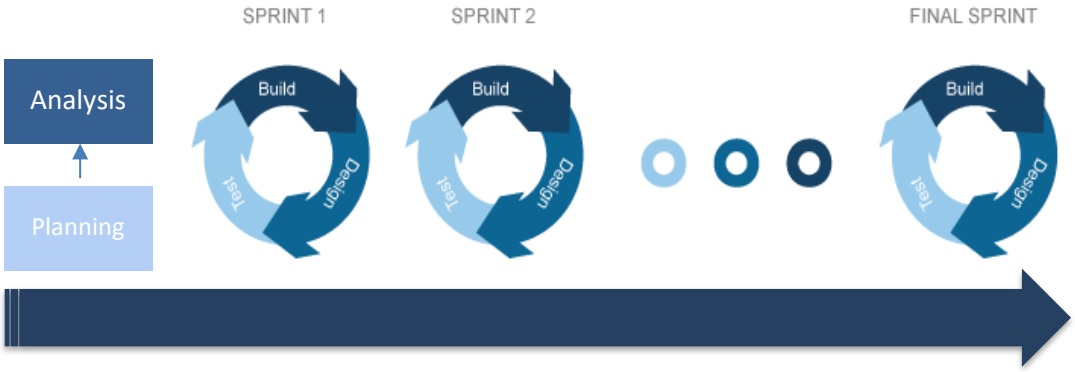


Figure 47: Proposed SDLC for CD-ERP Model

3) Participation of the Committee for Development Partners

Cooperation between universities and industry has existed for a long time in different forms, such as joint ventures, networks, consortia, and alliances, with several forms that may vary based on the engagement of the participants (Ankrah & Altabbaa, 2015). Within the framework of this research, it is not practical to discuss the different typologies or taxonomies of Academia-Industrial relationships as described in the literature, but rather to briefly discuss the participation of IT firms (represented by the Committee for Development Partners) in the proposed model, with an emphasis on IS development. Since academia–industrial collaboration occurs in different forms with benefits to both sides, the author only discusses to what level external companies should be involved in the CD-ERP model. The following list summarizes examples of companies' involvement in terms of IS development[2].

- Participating in the funding of consortium projects.
- Internships for fresh graduates, who will work for universities, and training programs for current employees.
- Exchange programs (e.g. secondment of programmers, analysts, developers).
- Use of companies' facilities (e.g., laboratories, databases, servers).

[1] For more information on the bimodal principle, refer to Section 2.6 of this thesis.
[2] This list is based on the framework presented in (Ankrah & Altabbaa, 2015)

- Cooperative research projects (in which universities and companies could establish a joint research project to address some issues that need to be solved or enhance features of the system).
- Consultancy and Advisory Boards in the form of General Assistance Units (including units enabling technology transfer between both sides).
- Technological brokerage companies which function as brokers between universities and industry.
- Supporting patenting and licensing agreements (licensing of intellectual property rights).

8.3.5. A Strategic View of the CD-ERP Model Using SWOT

When it comes to strategic planning techniques, SWOT is a very common planning tool. SWOT is a qualitative and descriptive assessment of strengths, weaknesses, opportunities and threats (Omer, 2019) – hence the abbreviation. It emerged in the literature in the 1960s with an uncertain origin, which some scholars have credited to Harvard Business School, while other scholars have attributed it to Stanford University. (Gurel & Tat, 2017). Its general idea is to use an organization's knowledge about its internal and external environments and to formulate its strategy accordingly (Sammut-Bonnici & Galea, 2015).

Strengths and weaknesses relate to internal factors that are likely to be within the realm of the control of the organization, while opportunities and threats relate to external factors in a broader situation or environment (Omer, 2019). An analysis of internal factors is used to identify the resources, capabilities, core competencies and competitive advantages that are inherent to the organization, while an analysis of external factors is used to identify market opportunities and threats by considering competitors' resources, the industrial environment, and the general environment (Sammut-Bonnici & Galea, 2015).

The benefits of SWOT analysis include: fundamental identification of the current state of an organization; summarizing the basic factors influencing the effectiveness of activities inside the organization and affecting the achievement of its goals (Omer, 2019), as well as the provision of useful information in matching the organization's resources and capabilities with the environment in which it operates (Gurel & Tat, 2017). Although SWOT analysis is very popular and useful in business management, it is criticized as being a high-cost tool, which brings little benefit. Most researchers describe it as a tool that has much to offer, but only as a starting point for a more comprehensive review later. Also, there are other alternatives and modern techniques available, such as PESTLE analysis (or

Political, Economic, Sociological, Technological, Legal and Environmental).[1] From this point of view, the author used SWOT due to its simplicity and to draw conclusions about the internal and external factors found by this study that might affect the applicability of the CD-ERP model in the Libyan context. This conclusion could be used to derive a strategic plan after further analysis (Gurel & Tat, 2017).

To conduct a SWOT analysis, a rich information and knowledge base is required about the current situation of the organization, with an emphasis on internal and external factors. Then, SWOT analysis is typically presented in a four-quadrant box (a 2x2 matrix) that provides a summary that is organized according to the four section titles (Strengths, Weaknesses, Opportunities, and Threats) (Gurel & Tat, 2017). The summary is conducted by looking at the strengths to take advantage of your opportunities, and looking at how these strengths can combat the threats. This analysis can be used to produce a list of comments, recommendations or actions to be taken.

In this section, the author uses SWOT analysis to describe the strengths and weaknesses of the CD-ERP approach. Then, a list of recommendations, actions, and comments are provided, which can be converted into a strategy when adopting the CD-ERP approach. It should be noted that SWOT uses the term "threats" to study the external factors that negatively affect a business strategy, such as possible competitors. At the same time, community-source models, such as CD-ERP, form an environment where each partner must view other partners as non-competing, in order to share some of the costs, risks, and potential rewards. Hence, the author uses the term "obstacles" instead of "threats" to express the external factors that might negatively affect the CD-ERP model when adopted in the Libyan context.

Table 32: SWOT Analysis of the CD-ERP model

SWOT ANALYSIS

[1] Also known as "PEST Analysis". It is a tool that describes a framework for the overall environmental factors in the strategic analysis which gives an overview of potential factors to be taken into consideration. Other alternatives are SOAR analysis (or strengths, opportunities, aspirations, and results) or NOISE analysis (needs, opportunities, improvements, strengths, and exceptions) (Sammut-Bonnici & Galea, 2015).

STRENGTHS	• Universities are organizations that share common characteristics with compatible business processes and, in particular, are geographically clustered. • A central organization (the Libyan Ministry of Education) delivers some common services to multiple IT sub-departments (of Libyan public universities) • Cooperation in IT has already been established between Libyan public universities. • HE is a sector based on knowledge sharing and collaborative development is a "perfect fit" for HE. • A pool of nationally available resources. • Highly qualified, talented and dedicated faculty, as well as knowledgeable staff members, who are specialized in the field of ISs to lead the development process. • Freshly qualified graduates in IS development. • Well-known service providers of ERP/CC. • The availability of a modern learning environment in CC.	**WEAKNESS**	• Issues of communication, coordination, control, development, and maintenance in a geographically dispersed team. • The issue of project management. • Security concerns regarding the ERP model in general. • The need for ERP customization. • Challenges of adopting CC, or multi-tenancy architecture, such as security, regulations or scalability. • Ensuring the balanced involvement of all the consortium members in decision-making. • Diverse requirements of various partners. • The issue of governance and the ownership of code. • Organizations of different sizes working together. • Changing goals or vision among the members of a community can lower the level of cooperation, or in some cases even terminate a project. • Each university might be specialized in a particular module. These types of expertise may not complement each other.
OPPORTUNITIES	• Huge opportunity to team up with other universities. • Central repository**:** all the business activities of universities (educational, research and other activities) to be supported by one integrated system. • Working jointly is expected to achieve greater revenue, as well as enable higher productivity and quality, at a lower cost. • Developing open source applications collaboratively can give results that meet the needs of all the participating institutions. • Leading-edge infrastructures and gathering data from all HE institutes at the national level under the Ministry of Education. • Avoid building the system from scratch by adopting ERP. • Tremendous opportunity to work with well-known international projects using a similar approach and learn from their experiences. • A door towards initiating other joint projects between universities, not just IS development.	**OBSTACLES**	• Decreasing government funding and increasing expectations from stakeholders. • The level of technology in Libya is low. • National rules and regulations related to adopting the CD-ERP Model. • Loss of expertise through retirement and employee turnover, as well as not being able to attract experts in IS development. • Bureaucracy in LHE. • Current instability in Libya. • Commitments of service providers.

This analysis is compiled from the case study responses, relevant literature and international experiences. Also, some factors were excluded from this analysis, since they are common to any situation in which an organization experiences a new shift (e.g. resistance to change or a lack of commitment from top management). The author has chosen to conduct this analysis at the end of the thesis since the application of SWOT needs a rich information and knowledge base to succeed. After constructing the SWOT table, the following questions arise: How should these strengths be used to take advantage of the opportunities? How should these strengths be used to overcome the obstacles that might threaten the implementation of the CD-ERP approach? How can one counteract the weaknesses in CD-ERP? The following list presents comments and recommendations as answers to these questions that can be converted into a real strategy in the future.

- In the CD-ERP approach, the Libyan Ministry of Education works as a reliable central organization and guarantor of the central repository that delivers common services to multiple IT sub-departments (of LHE institutes). Since LHE institutes in public services are in a whole funded by the government, the introduction of such an approach is made easier by forcing LHE institutes to follow it. This point may be viewed as a drawback, since the institutes do not have the final decision. It can, however, be taken as an advantage to overcome some expected issues, such as resistance to change.
- One of the promising opportunities is the development of cooperation between universities. In particular, the fieldwork in Libya has shown a low-level of capacity to develop ISs in these institutes when working separately, but that cooperation in IT has already been established between Libyan public universities.
- As an extension to the previous point, universities usually experience a loss of expertise through retirement and not being able to attract new members in IS development. This issue is solved by a fundamental aspect of the CD-ERP approach, namely, IS development is conducted jointly by the consortium. Indeed, when a new team is hired in one institute, they can be trained in another location by another member of the consortium. In particular, these institutes together have talented, dedicated, and knowledgeable staff members who are specialized in ISs to lead the development process, and supply of freshly qualified graduates in IS development.
- One of the obstacles is decreasing government funding and increasing expectations from stakeholders. By following CD-ERP, a consortium of Libyan universities is projected to create a pool of nationally available resources that should fill the deficit in government subsidies. As mentioned in Table 32, another opportunity lies in the leading-edge infrastructures and ability to gather data from all HE institutes at national level under the Ministry of Education. This should also overcome the issue of the low-level of technology in Libya.
- Another weakness in the CD-ERP approach is the need to customize the ERP system, which could result in difficulties when ERP providers update their system. Several solutions to this problem are available under the CD-ERP model,

including: the CD-ERP approach is built using multi-tenancy software architecture so that customization can be carried out during run-time. Hence, the original code of the ERP system will not be changed. Also, it is recommended to customize only the critical components of the system.

- Fair involvement of all the consortium members in decision making is another issue, especially when organizations are of different sizes. As illustrated in Figure 45, the consortium consists of two main bodies, namely: the Consortium Council and the Board of Executive Directors, together with other committees. Such a structure ensures that all members have a right to be involved in the decision-making process. Also, the consortium is non-profit, the fees collected are used to cover the costs of system development. The level of fees is based on the size of a member, so that even small institutes can join the consortium.
- Developing open source applications collaboratively can give results that meet the needs of the participating institutions. However, the diverse requirements of various partners is handled by the combination of the core members forming the "Board of Executive Directors", while the needs of other members are met by the "Consortium Council". This structure should ensure that the development process is not slowed down by the diverse requirements of these members. Also, Libyan universities are organizations that share common characteristics with compatible business processes and, in particular, are geographically clustered as shown by the fieldwork in Libya.
- The issue of governance and the ownership of code is another concern. In the CD-ERP approach, all the members have the rights to open-source ERP-based integrated systems. Source code is available on-demand to institutes participating in the project with no limits on internal end-users or installations.
- The active commitment of service providers, such as ERP vendors and CC providers, is crucial. Hence, the choice of service providers should be considered carefully, especially taking into account that these firms may become inactive.
- Some issues that commonly occur in a distributed environment, such as a lack of communication, control or even project management could be linked with the problem of a member becoming over-specialized in particular modules. Such issues could be solved by using the proposal that specialization in specific modules should be spread horizontally within the CD-ERP approach. Hence, modules are split horizontally between universities (one university manages the presentation/user-interface, another one manages the database, and another manages the web-based services). Such a structure should minimize the problematic issues that typically occur in a distributed environment (described above). In fact, this point brings us to a very interesting topic to be investigated in the future.
- There exists a tremendous opportunity to work with well-known international projects using a similar approach and learn from their experiences, especially since some projects, such as Sakai and Kuali, have already been implemented in other universities than the ones in which they were developed.

8.3.6. The Cloud Architecture

Based on Figure 48, as proposed by Mathew, any HEI can benefit from CC and avoid its drawbacks through the proposed architecture based on both a private Cloud and a community Cloud. For sensitive data and applications, universities can develop their own Cloud, a "private Cloud", by making use of their existing resources. For shared data and applications, universities can come together and develop a community Cloud, an "educational Cloud". Without any additional expense, the necessary computational facilities can be provided on demand in the appropriate Cloud, while a common platform can be created to share numerous resources from various universities (Mathew, 2012).

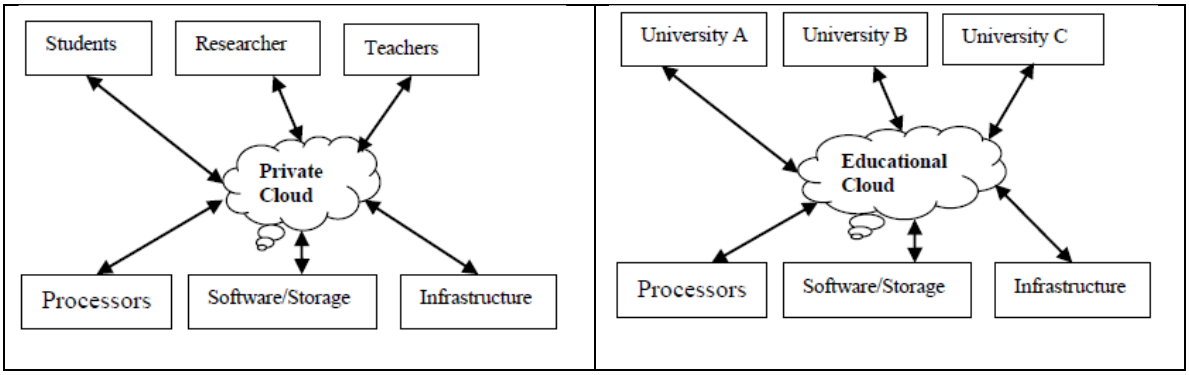


Figure 48: Private Cloud and Educational Cloud Architecture for HEI - Source: (Mathew, 2012)

In the model proposed by Almajalid, illustrated in Figure 49, the Saudi Ministry of Higher Education uses a public Cloud instead of a community Cloud. A hybrid Cloud was added to connect the public Cloud to the private Cloud used by universities (Almajalid, 2017).

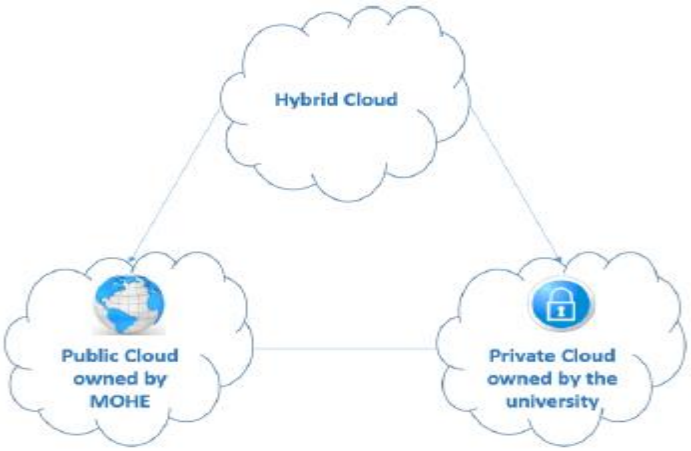


Figure 49: A model of a hybrid Cloud - Source: (Almajalid, 2017)

Based on the above, the following model of CC is recommended, as illustrated in Figure 50:

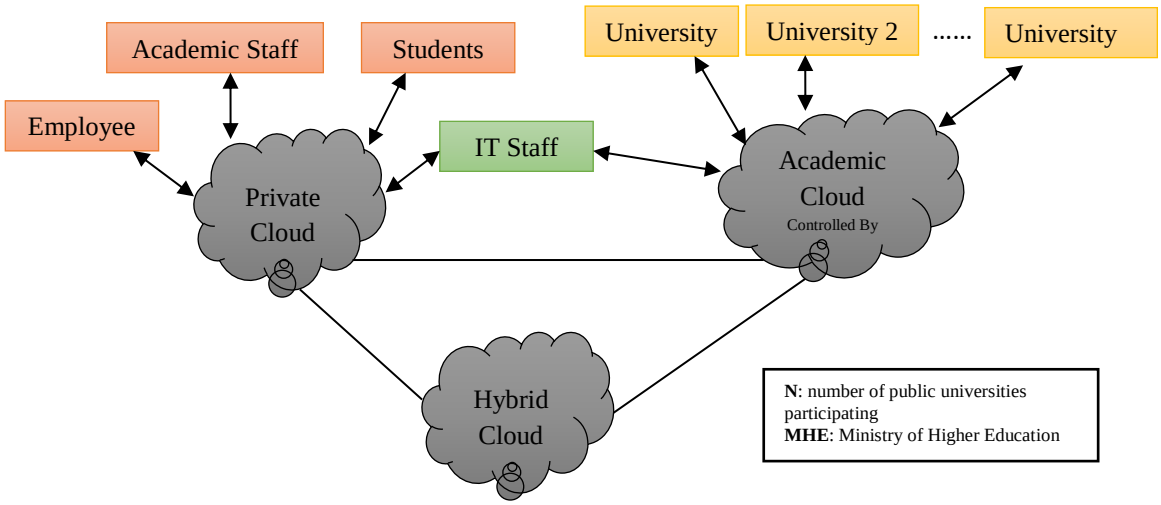


Figure 50: The proposed CC architecture for the CD-ERP Model - (source: author's own work)

- Each university possesses its own private cloud. Sensitive data and applications relevant only to a particular university are stored in this private cloud. The sharing of data on a private cloud with other universities is forbidden. The type of data held in a private cloud is referred to as a university's internal data, which will comprise all the data that an HEI owns.
- The Libyan Ministry of Education owns a community Cloud called an "Academic Cloud". Institutional data are generated by all of the universities participating in this academic Cloud. The ministry is responsible for ensuring that the integrity of the data stored in this academic Cloud is protected. Consequently, institutional data are shared with other universities, as well as being monitored and controlled by the ministry. This eliminates duplication and the universities' stakeholders (e.g. students, academics) would also benefit greatly from avenues for sharing knowledge and research among HEIs.
- The hybrid Cloud enables the portability of data and applications between the academic Cloud and the Private Cloud.

8.3.7. Parallels and Differences between CD-ERP Model and other Models

Based on the above, the CD-ERP model is consistent with other models in some terms, such as, being based on a community source model (collaborative approach); similar structure of the consortium; governed by a consortium of educational institutions; ISs are developed jointly; and the administration and the development costs are shared among the beneficiaries. On the contrary, the CD-ERP model differs in terms of targeting LHE and its unique characteristics. To the author's knowledge, this is the first study addressing such a collaborative approach in LHE. Due to the low level of ISs, and lack of capabilities to develop their own ISs in LHE institutes, the author included ERP as the base of the proposed model for LHE. Similarly, other international experiences have

adopted an approach in building their systems on existing code that works at least fairly well (non-ERP), as was the case for Sakai and Kuali. Such an approach negates the need for hard negotiations about basic decisions regarding the architecture of the system, as well as increasing the likelihood that the project can achieve rapid success to prove its potential value (Courant & Griffiths, 2006). Besides this, it is quite challenging to integrate a number of the existing projects (for example, Sakai) with other enterprise software systems, such as ERP (Monarch, 2010). The importance of ERP in the HE sector has been emphasized, especially since ERP systems are the most complex software applications adopted by universities and are accompanied by significant investments in their implementation[1]. It is also important to highlight that the CD-ERP model likewise relies on the way international experiences base their systems on existing code (in-house), but differs since ERP is proposed to be the basis of the system.

Moreover, the CD-ERP model includes other advanced technologies that community source projects may not be able to fully adopt or have difficulties in doing so. For instance, multi-tenancy was included to deal with the problem of customizing ERP. ERP customization is thought to be a barrier, due to the difficulties resulting from providers updating ERP in the case of heavy customization. Alternatively, multi-tenancy can support the ability to customize ERP during run-time, while not changing the actual source code of the ERP itself. As a result, ERP updates can be performed smoothly. Besides this, ease of customization enables each member to have their own version of the integrated systems developed jointly by the consortium (in-house applications) without changing the actual code of these systems. Furthermore, CC is included in the CD-ERP model, since it represents a great benefit to HE, especially when universities intend to work jointly. The growing interest in CC within the HE sector could be the result of many factors, such as the availability of a modern learning environment where users can access services at any time and from anywhere.

This description of these differences can be seen as a contribution to knowledge. However, the main contributions of this study to knowledge are discussed in the next section.

8.4. Contribution to Knowledge

The following list represents the main contributions of this study to academic knowledge.

1) The study has dealt with a form of community source (collaborative approach) to be applied in LHE. Community source is a collaborative approach to system development used by HE institutes that relies on the practice of open-source

[1] For further discussion, please refer to Section 2.3.6 “ERP in Higher Education (HE)”

software communities. In order to check the applicability of this approach for the development of ISs in LHE, this study has investigated the experiences from a range of international projects in this field; as well as the current status of ISs and system development in LHE (where three case studies have been conducted); and with supportive observations from the literature. To the author's knowledge, this study is the first to investigate either of these aspects.

2) The literature review has shown that the development of software is no longer confined to an individual developer, but is often based on a geographically distributed team. Also, the dimensions of communication, coordination, control, development, and maintenance must be taken into consideration in such IS development projects.

3) This research has included cases from other projects that have followed a similar approach via a study of the available documentation, as well as a brief interview with the leader of the USOS project in Poland. These cases have shown that community-source has been adopted by many universities and government bodies worldwide. Community-source was described as a "perfect fit" to the philosophy and standards of research and education. Moreover, it is clear that a collaborative approach to developing open source applications can give results that meet the needs of the participating institutions, as well as giving great potential to benefit the broader community. Although some of the ISs developed by these projects have reached the end of their lifetime, the consortiums themselves are still very functional. Besides, community-source is projected to overcome the historically encountered gap between software producers and the HE sector.

4) Some of the issues observed by the author during the survey of international projects are similar to those already described in the literature. Indeed, topical factors described in the literature, such as coordination and communication costs, resistance to change or project management are also common in community-source projects. On the other hand, challenges involved in integrating systems with ERP; creating a core team of selected partners; and building a system on existing code that works at least fairly well are factors that were discovered via the survey of international projects. These factors are particularly important in the context of LHE (see the discussion in *Section 8.2.2)*.

5) To test the hypotheses, this research has conducted an evaluation of the level of the ISs implemented in three Libyan universities used as a model to indirectly represent LHE. This research has provided a qualitative and investigative study of IS implementation using an assessment framework.

6) The assessment instrument is mainly based on the assessment framework developed by (Akeel, et al., 2013) that targeted Libyan oil companies. The author developed a modified version of the original assessment framework. Some modifications were applied to suit the unique nature of this research, such as the

separate treatment of online and offline systems, which has shown distinctive results. Also, the targeted populations are academic organizations (universities), rather than commercial organizations (oil companies), as is the case in the original framework. Moreover, various models, techniques, and tools were used in the modified assessment framework. This enabled a more systematic approach, which begins with a general evaluation and then proceeds to a more detailed analysis. These steps provide a logical sequence to follow.

7) The study provides a roadmap for other researchers to use (or to further develop) the current assessment framework in order to evaluate the level of IS implementation, as well as the capabilities for software development in HE institutes (especially universities).

8) The results from the fieldwork in Libya have indicated that the ISs implemented play a vital role in everyday tasks (such as making both short-term and long-term decisions based on information provided by these ISs). The information provided is considered reliable to some degree, but is not available on demand. The study has also shown the low-level of ISs implemented in all cases, as well as a lack of capability to individually develop such systems. Also, the comments of the experts indicate that top management in universities is convinced that most of the business activities need to be supported by applications based on the latest technology, but are unwilling to incur the expense of purchasing/developing new ISs. Moreover, the research has shown supportive findings to the applicability of a collaborative approach such as; cooperation in IT has already been established between Libyan public universities, the similarity between the case studies, and the positive feedback from some participants (particularly S-2, and M-2) about the applicability of a collaborative approach in LHE.

9) In this study, the three main sources of information (the observations from both the literature and international experiences, and findings from fieldwork in Libya) have led to suggesting the CD-ERP model as a potential solution in this context. To the author's knowledge, the academic study of such forms of collaborative development in LHE is a new topic and very few studies have been run so far. The name of the model proposed has been constructed from the fundamental elements of the model. As discussed above, this model has some aspects[1]. The proposed model includes the following: an outline for cooperation within the consortium, Cloud architectures, the proposed structure of the consortium, and recommendations for a successful and efficient transformation from a traditional system to a CD-ERP system. The collaborative approach for LHE, presented in the

[1] Please referrer to *Section* 8.3.7 of this thesis about the parallels and differences between CD-ERP model and other models.

CD-ERP model, is based on the idea of sharing resources among HE institutes to develop their own ISs, or at least to guide the development of ISs. It is recommended to base the overall system on a skeleton solution (ERP) to avoid developing systems from scratch.

10) Finally, the strengths and weaknesses of this approach in the Libyan context have been analyzed using SWOT to provide the reader with summarized conclusions.

8.5. The Limitations

The context of HE in Libya is specific to some extent. Hence, the generality of the findings are rather unclear. Indeed, case studies have often been questioned with regard to generating findings, as they deal with a small number of people, groups or organizations, not with the whole population. In this research, the author carried out several case studies of Libyan universities as a model to represent LHE indirectly. The author has tried to include as many cases as possible based on the timetable of the research. However, the case studies were limited to only three cases, due to the civil instability in Libya. The author used strategic selection of the case studies based on characteristics such as the establishment's history. Such selection is consistent with the fair representation of Libyan universities in the study. Indeed, the author categorized Libyan universities into three groups based on the size and history of an establishment, and then chose the leading university from each group. These choices can be used as models of other universities. In addition, the number of participants interviewed was relatively low. This is due to the research boundaries (the delimitations) set at the beginning of this research, in which the author limited the study to personnel who actively participate in the strategic process of implementing ISs. Indeed, ordinary users are not concerned about how the system is developed. They are rather concerned about functionalities, which are outside the scope of this research. The number of such participants would remain relatively small, even if other case studies were carried out. However, it is important to remember that the aim was to obtain qualitative insight into the level of ISs in the case studies, rather than capturing feedback from all kinds of users.

Furthermore, the author planned to study examples of international projects using a deductive method based on data collection. Online questionnaires based on the SERVQUAL model were constructed and sent to the coordinators of these projects in order to gather the appropriate data. Unfortunately, none of them replied to the author. The author recommends studying projects that follow a similar approach. It seems most practical to carry out such research on the basis of case studies.

Another limitation is validation of the CD-ERP model. Firstly, the study is a qualitative one in which there is no possible way to validate the results via simulation or practical implementation. In the field of IS management, it is extremely difficult to test a model unless prototyping is conducted. This means that at least one part of the system should be functional, which is impractical since the scope of such a study would be beyond

the scope of such a thesis. It is also important to note that the model itself is neither the main goal, nor the main contribution. It is rather one of the additional contributions (which can be considered as an output) of the thesis. Certainly, the study aimed to investigate the "applicability" of a collaborative approach in LHE, providing comprehensive insights into such approaches, due to all the factors discussed on various occasions in the thesis, and to evaluate the IS implementations in Libyan universities through the assessment framework.

Having a valid model is considered significant though. Given the fact of the qualitative nature of the research, "validation" can mainly be performed using experts' opinions, alongside other sources of data. Indeed, the results have been validated using different sources of data: (1) most importantly the findings from the fieldwork in Libya such as the feedback of IT experts regarding the status of IS implementations in the case studies, with an emphasis on their opinions about the applicability of a collaborative approach, (2) the observations and findings from international experiences, especially after the interview with the USOS leader, and finally (3) the support of the observations from the literature in which different factors have been considered in the conceptual framework of the study. In other words, presenting the findings in a solid manner is the best way to validate the CD-ERP model at this stage. Various data sources were included to explore different perspectives by explaining findings using logical and subjective viewpoints.

8.6. Future Work

This research is an introductory study and the scope is very general. It is recommended that more studies should be conducted on more specific topics, such as:

- Establishing a new research team that will carry out comprehensive interdisciplinary examinations and run more case studies on Libyan universities and community colleges in both the public and private sectors. Such a team is expected to cooperate with existing teams under the direction of the Ministry of Education. Such research should be carried out alongside the practical implementation of an integrated IS system for LHE based on the recommendations found in this thesis.
- Conducting studies on distributed ISs and the international experiences of using a community-source approach. Particularly, investigating the collaborative development of ISs in community source projects in Europe, with an emphasis on technological, organizational, and environmental factors using a modified version of the FITT (Fit between Individuals, Tasks, and Technology) framework. The FITT framework is very commonly used in the field of e-health management. Because of the unique characteristics of a collaborative approach, environmental factors should be considered as an essential dimension. In order to develop a comprehensive knowledge-base for all community source projects in Europe and due to the considerable number of these projects, the framework should be modified to provide a quantitative instrument after conducting the initial case

studies (2-3 cases to be conducted using qualitative means) to obtain faster findings from the remaining cases.

- Investigating the Circular Economy (CE) and its practices in the collaborative approach (community source projects). This new project is not related to a stereotypical understanding of CE practices in IT, such as e-waste or the retail and service sector (e.g. Amazon or Allegro). It is, however, about the CE practices in IS development (particularly a collaborative approach). There are some CE practices inherent in the collaborative approach that were detected during this study. Indeed, CE practices appear in community source projects, such as recycling systems rather than building them from scratch; or leasing products rather than owning them (e.g. multi-tenancy software architecture that is included in the CD-ERP model). It is recommended to use agent-based modelling to simulate scenarios of CE practices, in order to give insights into these practices and their long/mid-term impacts by comparing simulated scenarios with real data.
- Investigating the challenges faced by the two main approaches to adopting ERP systems, namely: reengineering into ERP (BPR) or customization ERP, with an emphasis on the environment of collaborative development.
- Investigating the factors that need to be considered when adopting a CC model with multi-tenancy, such as architectures, economic factors, performance, maintenance, and scalability.
- Security and privacy issues are important topics in the general field of ISs. These topics should be studied carefully from the point of view of the CD-ERP model as we are dealing with a variety of organizations in a distributed environment, hosted on a Cloud and based on multi-tenancy architecture.
- Studying the legal and regulative issues of adopting a CD-ERP model, such as legal matters within a consortium and among its members, contracts with ERP vendors and hosting on the Cloud.
- Studying the issue of disaster management under the CD-ERP model.
- Studying the applicability of Agile practices in the context of a community-source environment.
- Offline use is an interesting point and could be helpful in the case of unstable countries such as Libya, where the Internet can be often disconnected. For this reason, the Hub-and-Spoke architecture should be considered.
- Cooperation between academia and industry in a community-source environment should be studied, in particular, the role of IT firms in consortia, and the factors that influence this role.
- Conducting a comprehensive study using tools for strategic analysis, such as PESTLE, to make a systematic and thorough evaluation of the CD-ERP Model.
- This stage of the research does not address functional assessment of the CD-ERP model. However, it is planned to develop a prototype system based on the CD-

ERP model in order to assess the applicability of this approach in practice. Since this is an ambitious goal in itself, it is left for future research.

8.7. Conclusion

To finish, the author gives a brief discussion of the main issue of this research, namely what is an appropriate approach for IS development in LHE. The author has used Libyan universities as a model. Although only three Libyan universities were studied directly in this research, information about the ISs implemented in other universities was obtained indirectly. In particular, *the author argued that the ISs currently implemented in Libyan universities are at a low-level and the capabilities of universities to internally develop IS applications based on international specifications was questioned*. As discussed in Section 8.2.3, the results of this study have confirmed the low-level of ISs implemented, both commercial solutions and in-house developed applications, in the three universities studied. In particular, there exists the issue of duplicated ISs and old ISs are repeatedly being replaced with new ones. This indicates that top management and/or IT specialists are not satisfied with these systems. Also, none of the three universities have fully reached the "Integration Stage", based on an assessment using Nolan's model. This reflects the low-level of ISs within these universities, especially as UOT is considered to be the leading university in Libya. Additionally, as indicated by the system profiling and process mapping of ISs, most of the ISs (in-house or purchased applications) need to be replaced. It is a costly task to rebuild these ISs from scratch. Also, the participants in the fieldwork in Libya, who were experienced in IT, all expressed the opinion that universities are unable to hire highly qualified staff, which results in the low-level of the ISs implemented.

Most importantly, it is argued that CD-ERP will be easier to implement in the Libyan context because of the low-level of ISs implemented at the university level, the lack of capability for system development in individual universities and the central role that can be played by the Ministry of Education. This may, in fact, be a benefit. Accordingly, *the author argues that Libyan universities and LHE, in general, can benefit from introducing the CD-ERP approach* in which the disadvantage of high establishment and operational costs should theoretically be avoided in the Libyan environment. Based on this lack of capability at the level of individual institutions, Libyan universities or LHE institutes in general, may not have many options for adopting a well-functioning platform to start with. In this context, ERP offers a promising and alternative solution.

Technically, ISs developed on the basis of community-source have been successfully implemented, as shown by international experiences. However, the author proposes an approach, the CD-ERP model, based on two main principles, namely ERP packages and a collaborative development approach. In terms of ERP, Libyan universities would avoid building their systems from scratch by adopting ERP-based solutions (because there is no base system to start with). This is discussed in Section 8.2.2. International experiences indicate that building a system on existing code that already works at least fairly well is a

successful approach. Some international projects have faced difficulties in integrating their own systems with ERP packages. Besides the difficulties arising from the lack of integration with ERP, these projects did not restructure their systems to include ERP, taking into mind that the costs of the process of now rebuilding these systems using such technologies may exceed the expected benefits. However, when ERP systems are already available, universities can develop applications that are intentionally adapted to ERP.

In regard to collaborative development itself, the observations have shown other benefits that can be gained through following such an approach, as described in Section 8.2.2. For instance, following this approach is projected to enable higher productivity and quality at a lower cost, create a pool of locally available skilled resources, leading-edge infrastructures and gather data from all HE institutes at national level under the Ministry of Education. Moreover, HE is a sector based on knowledge sharing and collaborative development is described as a "perfect fit" for HE. Indeed, a model based on community-source can be viewed as a means of knowledge sharing, alongside other means of sharing, such as sharing costs or human resources. Again, the fieldwork in Libya has discovered that cooperation in IT has already been established between Libyan public universities, as shown in *Section 7.2.1*. Indeed, the author discovered that cooperation has been initiated between Libyan universities in IS development. Indeed, universities such as Al-Mergib University and Bani Waleed University recently adopted the SIS developed by UOT, which confirms that similarities exist between these cases. This reflects that the results of this research can indirectly give information on other Libyan universities that have not been specifically studied. The author recommends carrying out further case studies though.

As mentioned in *Section 8.2.2,* some authors consider community-source to be a transitional phase rather than a lasting model. The author would argue strongly against this point of view. Indeed, Sakai moved towards open-source development and joined the Apereo Foundation in 2012, while Kuali exhibits a similar history. However, Sakai and Kuali are only two cases from many worldwide projects. In fact, a considerable number of other projects across the world continue to use a collaborative model. This indicates the success of such an approach. Also, Sakai and Kuali have reported a large number of implementations, both locally in the US and internationally. Many institutes have asked to join these two projects, which reflects the fact that the Kuali and Sakai projects are based on a successful model, rather than being a transitional phase (Wheeler & Hilton, 2012) (Hanganu, 2008) (Feldstein, 2014). However, the possibility of community-source being a transitional phase should be seriously taken into consideration.

Furthermore, the author has gained knowledge on the Libyan side and community-source approach, since he has been working on developing ISs for UOT for six years (2010-2016), as well as conducting this study. In his experience, he has noticed that the issue of IS development is a very critical issue in the university environment. By nature, universities are not IS developing types of organization. At the same time, some

universities have shown great possibilities of doing so, especially since those universities provide fresh and qualified graduates in IS development, as well as employing university professors who are specialized in this field and can lead the development process. Also, the author has noted that UOT and other Libyan universities suffer from duplicated ISs, where individual departments develop or purchase IS applications that are at least analogous, if not identical. More attention is paid to the application/user interface layer, rather than the database. The author argues that no matter what application is used, the database should remain basically the same. This is due to the fact that, at present, different systems work with separate databases, so it is difficult to integrate these systems. Following the CD-ERP approach would ensure that a centralized database is built. Also, gathering expertise from various HE institutes in Libya should avoid the problem of a lack of capacity to develop ISs in individual institutes.

Based on what has been mentioned, the author concludes that the CD-ERP approach would open numerous doors of opportunity for HE institutes in Libya by pooling their resources and developing IS applications, or at least guiding the development process. However, careful planning to deal with any possible drawbacks is always recommended before taking any serious steps. The drawbacks of CD-ERP have been discussed in many parts of this thesis, together with possible solutions, such as the CC model, multi-tenancy architecture and a number of other recommendations.

8.8. Summary

In this chapter, the author has concluded the study with an analysis of the findings on the basis of the research questions that were formulated in *Section 1.3*. Based on the findings from a literature review, the case studies and international experiences, this chapter has also proposed a CD-ERP Model for successful and efficient transformation from the systems currently used in LHE. The structure of the consortium, cloud architectures and a number of recommendations have been presented. Furthermore, this chapter has presented the contributions of this study to academic knowledge. As stated above, this research is an introductory study aimed towards the implementation of a new model for IS development. The limitations of this study have been pointed out, as well as recommendations for future research.

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APPENDICES

APPENDIX I – List of Abbreviations

APPENDIX II – Final Draft of the Interview Questions

APPENDIX III – Final Draft of the Questionnaire for Studying the International Experiences

APPENDIX I – List of Abbreviations

Libyan Higher Education (LHE)
Enterprise Resource Planning (ERP)
Human Resources (HR)
Information System (IS)
Human Resource Information System (HRIS)
Critical Success Factors (CSF)
Decision support systems (DSS)
Knowledge management system (KMS)
Electronic Learning (E-Learning)
Materials Requirement Planning (MRP)
Customer Relationship Management (CRM)
Cloud Computing (CC)
Infrastructure as a Service (IaaS)
Software as a Service (SaaS)
Computing as a Service (CaaS)
Chief Information Officer (CIO)
Unified Cloud Interface (UCI)
Response-Driven Sampling (RDS)
Data Ownership (DO)
University of Tripoli (UOT)
Sirte University (SU)
Java 2 Enterprise Edition (J2EE)
University Centre for Informatization (MUCI)
Strengths, Opportunities, Aspirations, and Results (SOAR)
The Information Technology and Documentation Centre at Sirte University (SU-ITDC)
Mediterranean Coast for Information Technology Company (MCIT)
Libyan National Commission for Technical Education (LNCTE)
University Study-Oriented System "Uniwersytecki System Obslugi Studiow" (USOS)
French Agency of National University Modernization "Agence de Modernisation des Universités" (AMUE)
Strengths, Weaknesses, Opportunities and Threats (SWOT)
Software Development Life Cycle (SDLC)
Higher Education Institute (HEI)
Collaboratively-Developed ERP (CD-ERP)
Higher Education (HE)
Information Technology (IT)
Geographical Information System (GIS)
Transaction processing systems (TPS)
Executive information systems (EIS)
Electronic Commerce (E-commerce)
Electronic Business (E-Business)
Supply Chain Management (SCM)
Business Processes Reengineering (BPR)
Service Level Agreements (SLA)
Platform as a Service (PaaS)
Hardware as a Service (HaaS)
Data Storage as a Service (DaaS)
Student Information Systems (SIS)
Quality of Service (QoS)
Medium-Sized Enterprise (SME)
UK Department of Trade and Industry (DTI)
Misurata University (MU)
SERVQUAL (Service Quality) Model
Libyan Open University (LOP)
Felles StudentSystem, (FS)
Digital Archive of Misurata University (DAMU)
Libyan Higher Education and Research Network (LHERN)
Digital Archive of the University of Tripoli (DRUoT)
CPIT (Connect, Publish, Interact and Transform) Model
Information and Documentation Centre (IDC) at Misurata University (MU-IDC)
Political, Economic, Sociological, Technological, Legal and Environmental (PESTLE)
Information and Communication Technology (ICT)

APPENDIX II – Final Draft of the Interview Questions

Research Participant Consent Form

Title of the research: Enterprise Resource Planning (ERP) Collaboratively-Developed ERP Approach in Libyan Higher Education, a Multiple Case Studiy of Libyan Universities. A research will be submitted in partial fulfilment of the requirements for the Degree of Doctorate Study at the Faculty of Computer Science and Management, Wrocław University of Science and Technology, Poland.

Aim of the Research: this study is a contribution to cover the gap in research and literature on issues related to Information and Communication Technology (ICT) in the Libyan Higher Education (LHE) system, evaluating the LHE system (especially universities) and its readiness for implementing in-house applications, and finally trying to implement collaboratively-developed, cloud-based multi-tenant ERP systems (CD-ERP) within Libyan universities that serve all the Libyan public universities and the planners of the LHE at the Ministry of Education as well.

Your participation: An assessment of the Libyan public universities will be conducted based on the data obtained from this interview.

Name of Researcher: ALMIGHEERBI, Tareq Salahi - **Email**: t.almigheerbi@uot.edu.ly
Supervisors: Prof. David Ramsey and Dr Anna Lamek

I, the undersigned, confirm that (please tick box as appropriate):

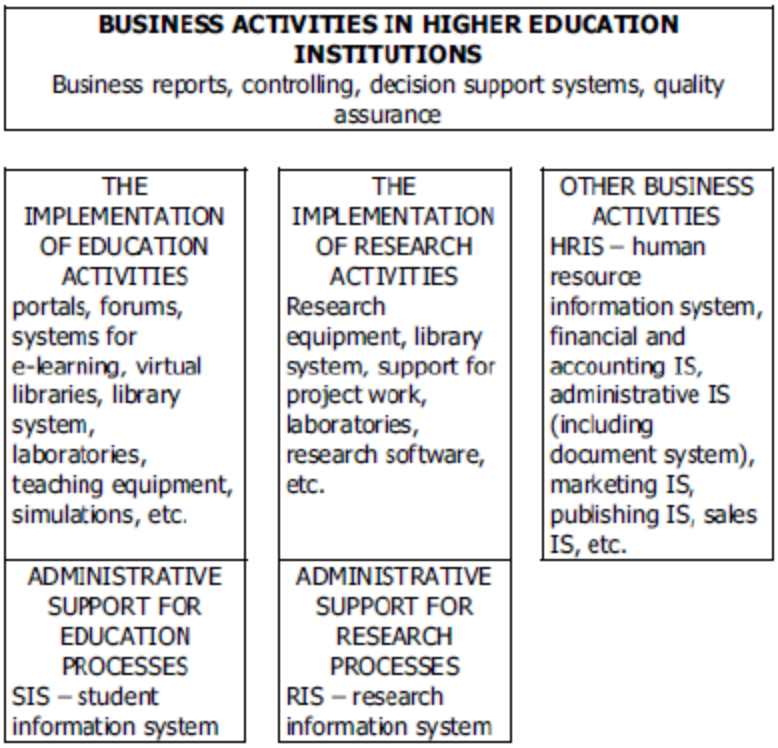
1.	I agree to take part in this study and participate in the interview.	☐
2.	If applicable during the interview, I agree to let the interviewee use separate terms of consent for interviews, tape/video recording or other forms of data collection.	☐
3.	I understand that my participation is voluntary and that I can withdraw from the research at any time without giving reasons.	☐
4.	I confirm that I have read and understood the information about the project, as provided in the Information Sheet.	☐
5.	I have been given the opportunity to ask questions about the project and my participation and my questions about the study have been answered to my satisfaction.	☐
6.	The use of the data in research, publications, sharing and archiving has been explained to me.	☐
7.	I understand that other researchers will have access to this data only if they agree to the terms I have specified in this form.	☐

Name of participant: ……

Signature: ……

Date: ……

SECTION		DETAILS	DESIRED INFORMATION
I		Information about the organization and its business	General Information
ITEM	**No.**	**QUESTION**	
Q	1	What is your educational background? What is your current position and how long have you held this position?	
A	1		
Q	2	In what year was the university established?	
A	2		
Q	3	In total, how many full-time students are studying at all departments across the university?	
A	3		
Q	4	In total, how many part-time students are studying at all departments across the university?	
A	4		
Q	5	In total, how many full-time staff members are working for all departments across the university?	
A	5		
Q	6	In total, how many part-time staff members are working for all departments across the university?	
A	6		
Q	7	In total, how many full-time employees are working for all departments across the university?	
A	7		
Q	8	What are your university's aims regarding the IT developing needed in the university?	
A	8		
Q	9	What problems do you encounter in meeting these aims (point by point) and rate according to the scale 1) minor, 2) serious, 3) very serious	
A	9		
Q	10	What are the main skills and qualifications that the IT staff must have?	
A	10		
Q	11	How do you rate the overall IT literacy of the staff – Excellent, Very Good, Good, Fair, Poor?	
A	11		
Q	12	Is there any further information you would like to add?	
A	12		



This figure represents Business Activities in a Higher Education (HE) institution (Zornada & Velkavrh, 2005)

Leo Zornada, Tamara Bertok Velkavrh, 2005, Implementing ERP Systems in Higher Education Institutions, MSc., 27th Int. Conf. Information Technology Interfaces ITI 2005, June 20-23, 2005, Cavtat, Croatia

SECTION		DETAILS	DESIRED INFORMATION
II		The university's processes and the sub-process	Business processes with associated IS
ITEM	**No.**	**QUESTION**	
Q	1	Are there any business processes carried out in your university not included in the above figure?	
A	1		
Q	2	If the answer in (A1) is (Yes), what are the other university's main business processes that are not mentioned?	
A	2		
Q	3	Does the above figure include any business processes that are not carried out in your university? If the answer in (A3) is (Yes), what business processes included in figure above are not applicable to your university?	
A	3		
Q	4	What are the main responsibilities of the IT centre/department in supporting the business processes of the university?	
A	4		
Q	5	What are the main benefits of the information systems of the university?	

A	5	
Q	6	What are the university's main business functional areas and the information system(s) for each function?
A	6	
Q	7	Which information system is used most in the university? If any, why?
A	7	

SECTION		**DETAILS**	**DESIRED INFORMATION**
III		Current Information Systems	Status of the information systems used in each business process found in section II
ITEM	**No.**	**QUESTION**	
Q	1	How many Information Systems (IS) are running at the University?	
A	1		
Q	2	What information system(s) are currently used in the university?	
A	2		
Q	3	Kindly explain how the information systems communicate, if they are more than one IS	
A	3		
Q	4	Please rate the following objectives according to the priority that is given to each by the university on the following scale: 1) Very important. 2) Important.3) Not important. (Please, specify "Not Applicable" if the objectives are not applicable to the university)	
A	4	Continuous enhancement and maintenance of information systems in the university. ( ) Increasing usage of e-business in the university's business activities. ( ) Periodic evaluation of adopted information system. ( ) Automation of all manual business processes in the university. ( ) Usage of information to drive decision-making. ( )	
Q	5	Does the university have a website/online system(s)?	
A	5		
Q	6	Kindly mention the benefits of the website/online system(s) to the business of the university.	
A	6		
Q	7	What are the main challenges in the current information systems of the university?	
A	7		
Q	8	How do you improve the information systems? Are there any plans to bring improvement or change to the current information system(s)? If yes, please provide details.	

A	8	

SECTION		DETAILS	DESIRED INFORMATION
IV		In-house application	The ability to develop sustainable information system, the cost of development
ITEM	**No.**	**QUESTION**	
Q	1	How many Information Systems (offline systems) have been (or are currently being) developed within the university?	
A	1		
Q	2	What are the current information systems (offline systems) developed within the university?	
A	2		
Q	3	Kindly explain how the current information systems (offline system) developed by the university communicate, if there are more than one.	
A	3		
Q	4	What are the technologies used for the current information system(s) (offline systems) developed by the university?	
A	4		
Q	5	Are there any website(s)/online system(s) developed by the university itself?	
A	5		
Q	6	If the answer to the above question is “yes”, what technologies are used for the website(s)/online system(s) developed by the university?	
A	6		
Q	7	Is there any communication between online and offline systems? If yes, kindly explain how they communicate.	
A	7		
Q	8	Kindly mention the benefits of the IS (offline system/website/online system) developed by the university itself to the business of the university.	
A	8		
Q	9	Kindly mention the weaknesses of the IS (offline systems/website/online systems) developed by the university itself with regard to the business of the university.	
A	9		
Q	10	Have the IS (offline systems/website/online systems) developed by the university met your expectations?	
A	10		
Q	11	Has the self-developing approach (in-house applications) been useful in improving your software development (analyzing, programming, etc) skills?	
A	11		
Q	12	What are the main challenges facing the information systems/ the website(s)/online system(s) developed by the university itself?	
A	12		

Q	13	Are there any plans to improve (or replace) the information systems/ the website(s)/online system(s) developed by the university itself? If yes, please provide details.
A	13	
Q	14	How do you think the IS should be developed?
A	14	
Q	15	Do you think that the university has enough technical staff to keep developing these applications?
A	15	
Q	16	On the basis of your experience on an in-house application approach, would you agree to encourage the university to invest more in this approach? (only applicable if the interviewee has such experience)
A	16	

SECTION		**DETAILS**	**DESIRED INFORMATION**
V		ERP implementation	Level of utility, venders, the cost of implementation
ITEM	**No.**	**QUESTION**	
Q	1	What is your knowledge about ERP (Enterprise Resource Planning) systems?	
A	1		
Q	2	a) How many ERP systems are currently in use by the university? b) How many ERP systems are currently actively being planned/introduced?	
A	2		
Q	3	(if applicable) Kindly explain how these ERP system(s) communicate with other systems developed by the university (in-house applications)	
A	3		
Q	4	If there are more than one ERP systems, kindly explain how they communicate with each other.	
A	4		
Q	5	Who are the venders of the ERPs implemented in the university?	
A	5		
Q	6	Are any of these/this ERP system(s) open to be modified by the university?	
A	6		
Q	7	Kindly mention the benefits of the ERP system(s) to the business of the university.	
A	7		
Q	8	Kindly mention the weaknesses of the ERP system(s) with regard to the business of the university.	
A	8		
Q	9	What are the main challenges facing the ERP system(s) in the university?	
A	9		

Q	10	Are there any plans to improve (or replace) the ERP system(s) implemented in the university? If yes, please provide details.
A	10	
Q	11	How do you think the ERP system(s) should be delivered? (in what sense – fully built, can be adapted etc.?)
A	11	
Q	12	Do you think the university has enough financial resources to cover the expenses and technical requirements of the ERP approach? In your opinion, what is the total cost of this process?
A	12	
Q	13	On the basis of your experience on the ERP approach, would you agree to encourage the university to invest more in this approach?
A	13	

APPENIX III – Final Draft of the Questionnaire for Studying the International Experiences

Quality of Service Survey

Title of the research: Enterprise Resource Planning (ERP) Collaboratively-Developed ERP Approach in Libyan Higher Education, a Multiple Case Studies of Libyan Universities. A research will be submitted in partial fulfilment of the requirements for the Degree of Doctorate Study at Faculty of Computer Science and Management, Wrocław University of Science and Technology, Poland.

Aim of the Research: this study is a contribution to cover the gap in research and literature on issues related to Information and Communication Technology (ICT) in the Libyan Higher Education (LHE) system, evaluating the LHE system (especially universities) and its readiness for implementing in-house applications, and finally trying to implement collaboratively-developed, cloud-based multi-tenant ERP systems (CD-ERP) within Libyan universities that serve all the Libyan public universities and the planners of the LHE at the Ministry of Education as well.

Your participation: An investigation on the experiences of international universities that have already followed this approach will be conducted based on the data obtained from this questionnaire.

Name of Researcher: ALMIGHEERBI, Tareq Salahi - **Email**: t.almigheerbi@uot.edu.ly

Supervisors: Prof. David Ramsey and Dr Anna Lamek

Notices:

- ✓ *Please circle a response for each question. If two responses apply, circle both.*
- ✓ *Please fill out both parts of this questionnaire.*

PART 1 - GENERAL INFORMATION

Q1: Name (optional): ……..

Q2: Age

○ 21-29	○ 30-39	○ 40-49	○ 50-59

Q3: Mode of Work

○ Part-time	○ Full-time

Q4: What is the highest level of your formal education?

- ○ GCSE or equivalent
- ○ A level or equivalent.
- ○ Bachelor degree
- ○ Master Degree
- ○ Doctoral Degree

Q5: How long have you been in this job?

○ Less than 1 year	○ 2-3 years	○ 4-5 years	○ More than 5 years

Q6: What is your profession?

○ IT support	○ Programmer	○ Analyst	○ System Designer
○ System Developer	○ Networking Specialist	○ Manager	○ Others (…specify…)

PART 2: ASSESSMENT OF SERVICE QUALITY

To how much you agree/disagree to the following points:

Q1 This approach uses up-to-date techniques.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q2 Its physical facilities are visually appealing.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q3 The work environment is convenient and attractive.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q4 By following this approach, when a specific task is promised to be done by a certain time, it will be.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q5 By following this approach, services are normally performed right the first time.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q6 By following this approach, services are provided at the time required/ promised.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q7 By following this approach, correct/accurate information is provided if it is needed.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q8 By following this approach, the organization show sincere interest in solving problems

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q9 By following this approach, the system has error-free records.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q10 By following this approach, users' behavior exhibits confidence in the system.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q11 By following this approach, services are trusted by the users.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q12 By following this approach, the system has the required technology to answer users' questions.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q13 By following this approach, prompt services are provided to the users.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q14 By following this approach, a help function is always available.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q15 By following this approach, the organization is never too busy to respond to users' requests.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q16 By following this approach, the organization understands the specific needs of users.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q17 By following this approach, the organization gives users individual attention.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree

Q18 By following this approach, the organization has users' best interest at heart.

○ Strongly agree	○ Agree	○ Neutral	○ Disagree	○ Strongly disagree