**Chapter One**

**INTRODUCTION**

1. **E-Learning Problem**

E-Learning has been widely used to refer to computer based systems that not necessarily help main objectives of e-Learning. The main goal of introducing e-Learning is to revolutionize learning process; as technology has already revolutionized business. Utilizing modern technologies and new approaches to achieve brighter future learning that is not available today is the main goal of introducing e-Learning. Unfortunately, utilizing technology within learning process has not achieved objectives because requirements were not addressed correctly and clearly. Besides, the main learning process was neglected, only technological aspects were the main concern. In order to present effective e-Learning, requirements, current shortages, technological limitations should be addressed clearly and correctly to determine technological capabilities that satisfy requirements and overcome problems and shortages, and start walking in the right way towards effective future e-Learning. Learning should be leading technology towards effective future e-Learning, and technology should not be limiting it.

1. **e-Learning**

E-Learning is defined as the learning process created by interaction with digitally delivered content, services and support [1-3]. E-Learning involves intensive usage of Information and Communication Technology (ICT) to serve, facilitate, and revolutionize learning process. [4-8].

**2.1 Learning Models**

Figure 1.1 shows the three main learning models that are fully enabled by e-Learning [4-7]:

* **Traditional Learning** is the agreed on learning today learning, where students heads to a school/college to learn. Usage of ICT can enhance the learning process. Data show and power point slides usage; as an example; is a common implementation of e-Learning within traditional learning institutions [5].
* **Distance Learning** is the Educational situation in which the instructor and students are separated by time, location, or both. Education or training courses are delivered to remote locations via synchronous or asynchronous means of instruction [9]. Distance education does not preclude the use of the traditional classroom [10].
* **Blended Learning** is the combination of multiple models to learning [11]. It refers to learning models that combine traditional classroom practice with e-learning solutions. For example, students in a traditional class can be assigned both print-based and online materials [4].

Argues that claim each model’s efficiency and effectiveness are widely available [9]. What matters the most is that ‘e-Learning’ was mentioned in the three models; unfortunately with a different perspective.

Figure 1.1: Learning models

1. **Management Information Systems**

E-Learning tends to revolutionize and manage the learning process [12], not only to manage universities. University Management Information Systems are not by itself the e-Learning.

**3.1 University Management Information System**

Managing universities activities requires University Management Information System (UMIS). UMIS refers broadly to a computer-based system ‘collection of hardware, software, people, data, and information’ that provides managers with the tools for organizing, evaluating and efficiently running their departments [13, 14].

Examples of UMIS components include Student Information System (SIS), Library Information System, Faculty Information System, and Finance System as illustrated in figure 1.2.

Figure 1.2: A Prototypical University Management Information System

* + 1. **Student Information System (SIS)**

SIS is the information system responsible for managing students’ data within the faculty and/or university. SIS typical student record includes ID, SSN (Social Security Number), Name, Age, Gender, Address (Street, City, Country), Email, Username, Password, DOB (Date Of Birth), Faculty, Year, Department [15].

SIS by itself is not an e-Learning system because personal data that SIS provides and manages differs in nature than data required for education [16]. Learner should be able to get a student profile that includes data like

* Detailed records of what learners have already learned (at the level of learning object, rather than a module or program).
* Profile of learning preferences.
* Development portfolio of transferable skills. A learning portfolio might also include a history of their interactions with their tutors, peers, and other significant learning conversations they may have had.

This kind of data is intended to be used to force learning process to be a learner oriented process[[1]](#footnote-2) by adapting learning system to fit learner requirements, personal characteristics and capabilities. Unfortunately, SIS does not serve this purpose, and does not handle such data.

* + 1. **Library Information System**

Library Information System is responsible for managing and automating libraries within faculties and/or universities. Automated Libraries are libraries that contain material in digitized form [17]. Automated Library Information System database record reflects the managerial tasks performed by librarians in order to effectively manage libraries. A typical Library Information System record will includeBook ISBN, Name, Author(s), Keyword(s), and data like Section, List of all the books, List of books available, List of borrowed books, who is borrowing, when they should return, etc.

Automated Library Information System by itself is not e-Learning because library information systems do not serve the learning process. Learner should be able to access fully available digital libraries as part of the learning process.

* + 1. **Faculty Information System**

Faculty Information System is responsible for managing and automating managerial activities related to Instructors, Employees, Courses, and intersection between them. A typical faculty information system database record includes Faculty data; ID, Name, Departments, Courses data; Course ID, Name, Description, Instructors data; ID, SSN (Social Security Number), Name, Age, Gender, Address (Street, City, Country), Email, Username, Password, DOB (Date Of Birth), Faculty, Year, Department; and Employees data; same as instructor’s data with customized data about job [15].

Faculty Information System by itself is not e-Learning its main goal is to organize faculty and/or university managerial activities; the learning process is not the main orientation. Faculty information system capabilities are to generate courses report(s), for example, that includes course managerial issues. In order for faculty information system to be an e-Learning enabler, learning considerations should be considered, not just managerial.

* + 1. **Finance System**

Finance system is responsible for managing financial issues related to any organization, even if this organization is a faculty and/or university. All learning involved partners agree that learning is not about financial issues, so finance system by itself is clearly not e-Learning.

* 1. **UMIS Role**

UMIS achieved success over the years and proved efficiency and effectiveness within educational institutions. UMIS is required for any successful e-Learning implementation in the three learning models, but with constraints about the role it should play. UMIS manages educational institutions, and more attention should be paid to the learning process with the presence of UMIS [18].

1. **Prototypical e-Learning**

Researchers attempt to define a prototypical e-Learning model over the years, resulting in many considerations, points of views, and acronyms that are hard to count. Each acronym reflects its presenter point of view, and features that must exist; from her/his point of view. Acronyms include [19]: Distance Education [20,21], Telecast [22], Adaptive Teaching System [23], Authoring System [24], CAI: Computer Assisted Instruction [25,26], Electronic Courses [27], Online Courses [27], CIT: Computer-Information-Television [28], Computer Managed Learning System [29], Computer Assisted Learning [29], Integrated Student Information System [30], CBT: Computer Based Training [31], LMS: Learning Management System [32], Interactive Learning Environment [33], Course Management System [34], Courseware Authoring Tool [35], Assessment Management System [36], Integrated Learning System [37], CAPA: Computer Assisted Personalized Approach [38], Collaborative Learning [39], Virtual College [27], VLE: Virtual Learning Environment [40], Virtual Conference [41], Virtual Classroom [42], WBT: Web Based Training [43], LCMS: Learning Content Management Systems [43], Web-based Interactive Course [44], PLE: Personal Learning Environment [45], Virtual University [46], Enterprise Course Management System [47]. By studying all mentioned acronyms, it is clear that there is confusion between tools, features, and concepts. In attempt to organize those acronyms, extract features, and tools that enable those features, clarify concepts, and keeping in mind that the learning process is our main concern, figure 1.3 attempts to clarify one of the ways to categorize those acronyms. Though digital library have not been mentioned explicitly as a main enabler of e-Learning, but it deserves to be added as part of the extended LMS due to its importance for the learning process.

Figure 1.3: e-Learning umbrella covers many acronyms

e-Learning implements technology that enables Virtual/Digital University, and/or Personal Learning Environments. Virtual/Digital University is the University that implements Online Learning Management Systems / Virtual Learning[[2]](#footnote-3) Environments and provides tools for Virtual College. E-Learning is the main concept that includes enabler technologies implementation for both Virtual/Digital University and Personal Learning Environments (PLE).

PLE represents a new trend in e-Learning that claims student’s right to use only one gateway to be able to access different LMSs provided by different universities. Those different LMSs should be personalized and integrated within this gateway [45].

Universities and colleges are digitized by implementing ICT. The maximum extent of digital university is the Virtual University; where the whole learning process is managed and maintained digitally. LMS/VLE and Extended LMS are the main implementation of e-Learning today.

* 1. **Learning Management System / Virtual Learning Environment**

LMS and VLE are different acronyms for the same concept. For the rest of this thesis, LMS will be used to refer to both LMS and VLE. LMS is the Software that automates the administration of training. The LMS registers users, tracks courses in a catalog, records data from learners; and provides reports to management. An LMS is typically designed to handle courses by multiple publishers and providers. It usually doesn't include its own authoring capabilities; instead, it focuses on managing courses created by a variety of other sources [2,3]. A prototypical LMS is presented in [40]. LMS features can be categorized into four main separate systems as depicted in figure 1.4. Those four separate systems are concerned with Courses, Exams, Assessments, and Collaborative features. LMS can be thought of as the integration of four separate systems, each system presents specific functionalities via specific tools. Figure 1.5 depicts the most common features that should be available in each of those four separate systems.

Figure 1.4: Main functionalities served by LMS

Figure 1.5: LMS components’ functionalities

* 1. **Extended LMS**

Extended LMS includes functionalities that must not be mandatorily provided by LMS, but are preferred to exist. Intercommunication means and digital library are two examples of those functionalities. Virtual intercommunications means enhances communication between instructor, students, and instructors/students, and enables virtual communities to exist.

* + 1. **Online Conferencing**

Conference is a prearranged meeting for consultation or exchange of information or discussion, especially one with a formal agenda [48]. Providing conference capabilities over internet is what is called Online Conferencing. Online Conferencing can be presented in one of three main forms:

* **Data Conferencing** [49]**:** Sharing data interactively among several users in different locations. Data conferencing is made up of whiteboards and application sharing and are often used in conjunction with an audio or videoconferencing connection.
* **Whiteboards:** A whiteboard is the electronic equivalent of the chalkboard or flip chart. Participants at different locations simultaneously write and draw on an on-screen notepad viewed by everyone.
* **Application Sharing and Application Viewing:** Application sharing is the same as remote control software, in which multiple participants can interactively work in an application that is loaded on only one user's machine. Application "viewing" is similar to application "sharing;" however, although all users can see the document, only one person can actually edit it.
* **Audio Conferencing:** An audio communications session among three or more people who are geographically dispersed. It is provided by a conference function in a multiline telephone or by the telephone companies or using internet [50].
* **Video Conferencing:** A real time video session between two or more users or between two or more locations. Videoconferencing may comprise any number of end points [51].
  + 1. **Virtual Classroom**

Virtual Classroom can be defined as the online learning space where students and instructors interact [10]. Virtual Classroom provides unique online features [52]

* Chat: two participants can exchange text to share thoughts between them.
* Discussion: Chat between more than two participants. Discussions can be public or private among part of the students.
* Question and Answer (Q&A): Individual participants may ask questions. Instructors may provide public or private answers.
* White Board: enable instructor to draw or display whatever compatible components.
* Group Browser: Participants can type the URLs in the address box, and sites are displayed to the entire group.
* Break Out Sessions: allows a subset of learners to enter a private chat area and use the virtual classroom tools.
  + 1. **Digital Library**

Digital libraries are libraries that contain digital materials [17]. Digital Libraries implementations might include digital data from academic institutions, public libraries, government agencies, and museums [53]. Digital libraries play an important role in the learning process due to the tremendous amount of different digital data available to be accessed by any of the LMS components anytime, and anywhere. Digital data can be implicitly provided to instructors, and students without the awareness of the presence of the digital library.

1. **UMIS or LMS**

Universities require both UMIS and LMS for efficiency and effectiveness [19]. Neither UMIS nor LMS can replace the other. Figure 1.6 clarifies this distinction by presenting that University managerial requirements are addressed by UMIS, and Learning Process requirements are addressed by LMS, so University needs to implement both systems.

Figure 1.6: University systems

Sociotechnical systems recognized many years ago that organizations functioned most effectively when their social and technological networks were compatible [54]. Unfortunately, LMS providers attempted to overcome UMIS functionalities and include them into LMSs, leading to the malfunction of the learning process, and resulting in many LMS shortages as will be presented in section 7.

1. **Current LMS**

List of current LMSs include: .LRN [55], BlackBoard [56], Centra [57], COSE [58], LON-CAPA [59], Moodle [60], The Learning Manager [61], Angel [62], ATutor [63], Claroline [64], Desire2Learn [65], Eledge [66], IntaLearn [67], KEWL [68], WebMentor [69], Janison Toolbox [70], KnowEdge eLearning Suite [71], Unicon Academus [72], BSCW [73], Colloquia [74], eCollege AU+ [75], ILIAS [76], Internet Campus Solution [77], MimerDesk [78], SAKAI [79], and IBM Lotus [80]. Figure 1.7 categorizes presented LMSs as Open Source, Free, or Commercial. Open source LMSs are LMSs that binary download for source code is available. Free LMSs are LMSs that installer download and usage in free and unlimited, with no source code available. Commercial LMSs are neither open source nor free. Users pay for purchasing and running commercial LMSs. By surveying LMSs, it is clear to find that most LMSs implement same features as depicted in prototypical LMSs as the one depicted in [18]. One of the LMSs will be discussed in details in the next subsection.

Figure 1.7: LMSs License Categories

* 1. **IBM Lotus LMS**

IBM Lotus is one of the leading LMSs that implements too many complicated features at a high level [81,82]. IBM Lotus is one of LMS dominants [83]. Figure 1.8 presents a detailed Lotus architecture and list of functions that are performed by Lotus components.

IBM Lotus is AICC certified since 1997 [82]. By studying Lotus preview [84] and architecture [85], it becomes clear that it is not applicable to satisfy all the educational institutions requirements within one LMS no matter what efforts are attempted by companies. Concerning Lotus as one of LMS leaders, neither the presence of 11 servers nor letting down some of the functionalities is acceptable. Issues like scalability, interoperability, and integration have been mainly serious issues for current available commercial LMSs that forced many educational institutions towards in-house LMS development and implementation to satisfy educational institutions special requirements.



Figure 1.8: Detailed Lotus Architecture

1. **Evaluation of Current LMSs**

Research is an academic activity that comprises defining and refining the problems, formulating hypothesis or suggested solutions, collecting, organizing, and evaluating data, making deductions and reaching conclusions, and at last carefully testing the conclusions to determine whether they fit the formulating hypothesis [86]. Evaluation is a main step of scientific research that enables in concluding and reporting research results, efficiency, effectiveness, and goals achievement. Evaluation utilizes many of the same methodologies used in traditional scientific and social research, but because evaluation takes place within a political and organizational context, it requires group skills, management ability, political dexterity, sensitivity to multiple stakeholders and other skills that scientific and social research in general does not rely on as much [87]. Evaluation-is the collection and analysis of information by various methodological strategies to determine the relevance, progress, efficiency, effectiveness, and impact of programs activities [88 - 90]. Evaluating LMS is not like evaluating any software system, because LMS should address pedagogical aspects, beside architectural and managerial aspects as depicted in figure 1.9.

**Figure 1.9: LMS Evaluation Framework**

**Managerial LMS Evaluation:** Total Cost of Ownership (TCO), among other methodologies like Cost-Benefit Analysis (CBA), is widely used as an analytical and justification tool for software assessment, replacement, and acquisition projects. Unfortunately, TCO analysis is time-consuming to complete based on assumptions, and sometimes hard to quantify. TCO evaluation of a Financial Information Systems is available in [91]. Same TCO managerial evaluation model can be applied from the managerial perspective to LMS. Managerial LMS Evaluation is out of scope.

**Pedagogical Evaluation:** Pedagogically, LMS shall enable universities and educational institutions to provide educational services in an easy, effective, and efficient manner. LMS providers and evaluators must be aware of pedagogical effects that will affect instructors and students. Current LMSs do not provide the required pedagogical effects [7]. One of the reasons is technology limitations. If technologies applied in LMS will not enhance learning process then pedagogically it is not a necessity and unfortunately this is the case today.

**Information System Evaluation**

One of the most important models to be used in evaluating information systems is the one presented by the standard ISO-IEC 9126. Figure 1.10 presents other architectural parameters that can be used in evaluating information systems. Presented parameters has not been addressed by ISO-IEC 9126 Standard, but still can be used by information systems evaluators. It is evaluators’ responsibilities to determine the most valuable architectural aspects to be considered in the evaluation process. Another architectural evaluation model that deserves mention and well consideration is the one presented in [92].

**Figure 1.10: Non-ISO Addressed IS Quality Parameters**

The study of most well known LMSs; including Lotus, has lead to the realization of the reality that there are many shortages of current LMSs affecting e-Learning in educational institutions This part tends to present some of the shortages addressed through evaluations of current LMSs. Some of the addressed deficiencies are: Integration, Agility, Scalability, Extensibility, Flexibility, Interoperability, and Redundancy.

**7.1 Integration deficiency**

E-Learning solutions are clearly a combination of two main categories of applications: LMS and UMIS. As presented in figure 1.11, there are four integration challenges:

* Integration between each category composing applications.
* Integration between the two categories.
* Integration between educational institutions allover the world.
* Integration between educational institutions and external institutions.

Figure 1.11: University Integration Challenges

**7.1.1 Category components integration**

Composing applications might come from different software vendors, legacy applications that have been running for a long time needs to be integrated with new applications, and new software applications might be installed. Existing applications might stand in the way of installing new applications due to integration problems.

**7.1.2 UMIS and LMS integration**

UMIS advances LMSs by decades [19]. UMIS achieved stability levels that most major educational institutions are running the same UMIS for almost a decade with no noticeable problems. LMS is the new concept that needs to be added to educational institutions, and it has to integrate with long time running UMIS. Due to differences in nature of design objectives between UMIS and LMS, integration issue should be addressed clearly. There will be new features that university will be able to provide incase full integration of UMIS and LMS took place. The capability of presenting individualized assessments that can be generated by integrating SIS; which will include two profiles for student; a managerial profile, and an educational profile; and the assessment management system should be addressed.

The capability of presenting individualized learning plans by integrating CMS and SIS that holds the learning profile should be addressed. Personalized courses will be generated based on learner history profile. It is not acceptable by learning experts to fix time and change amount to be learned, instead, amount to be learned should be fixed and personalized. Such individualizations enable PLE.

**7.1.3 Integrate different LMSs**

It is hard to find an educational institution that implements only one LMS because educational institutions requirements are hardly met by one LMS [7]. Different LMSs, either within the same educational institutions or over different ones needs to be integrated. Integration over courses level as provided by utilizing SCORM and AICC is not the typical solution of integration problems, because educational institutions need to share more than courses.

**7.1.4 Integrate educational institution and external institutions**

Educational institutions are not isolated islands that work alone, but they are part of the society. Educational institutions need to be integrated with all other governmental institutions. Tasks like generating a report with all current certain grade students, or students that are qualified for certain task because they have attended certain courses should be easily executed. Querying the educational institutions databases should be available efficiently. Student’s data shall be available to give the student ability to transfer his data between educational institutions as required.

* 1. **Agility deficiency**

From certain perspective, educational institutions are organizations, just like any other organizations. Organizations need agility, and so do educational intuitions. Agility is the ability to sense change and opportunity, respond quickly, and execute successfully. Educational institutions need to reflect governmental new or modified rules on current UMIS, overcome merge and acquisitions challenges, and provide new and customized services based on new added system features. An example of new customized services that should be presented when new system features are added is collaborative assignment. Collaborative assignment can be provided by the system after installing new collaborative tools. If the system were not built with agility in mind, new features adding or existing features editing becomes almost impossible, limiting the system from adapting and presenting new functionalities.

**7.3 Scalability deficiency**

System should expand and contract its resource pool easily to accommodate to heavier loads. Client – Server based LMSs can not scale to support large number of components, or interactions among components, within an active configuration [92]. Most today’s LMSs are Client – Server based [41]. Scalability needs to be addressed to offer educational institutions with the LMS solutions that satisfy the increasing requirements.

**7.4 Extensibility deficiency**

Extensibility is the ability to add functionality to a system. Dynamic extensibility implies that functionality can be added to a deployed system without impacting the rest of the system [92]. That implies not only adding new features to existing LMS without the need to install the new version, but also adding customized functionalities required by the educational institution. Unfortunately, current LMSs are released periodically to provide new functionalities, with the need to install the new version every time. Besides, most commercial LMS are categorized according to functions available by each product level, without guarantee on what are exactly the actions required to be taken to make the move to the next level incase required.

**7.5 Flexibility deficiency**

Flexibility is the ability of a system to respond to potential internal or external changes affecting its value delivery, in a timely and cost effective manner. The ability to change or to be changed according to circumstances is not by default provided by Client – Server architectural based LMSs, and unfortunately most LMSs are Client – Server based [41]. Changes include addition/loss of servers, and types of services provided by the system.

* 1. **Interoperability deficiency**

Interoperability is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units [93]. Interoperability is concerned with processes require the system to communicate with external systems to accomplish tasks. Educational institutions need to interact with external systems to achieve tasks successfully. Interoperability between LMS and external systems needs to be addressed and enabled. Current commercial LMS architectures and used protocols are not provided with LMS. A standard interface to LMS functionalities is required.

* 1. **Redundancy**

Redundancy refers to the unmanaged, uncontrolled, and unwanted more than single time occurrences of either data or functionality.

* + 1. **Data Redundancy**

Data redundancy refers to existence of the same piece of data in more than one place. Data is said to be in consistent state when all data redundancy are controlled. Data redundancy should be controlled for insert, update, and delete queries. Figure 1.12 depicts an example of uncontrolled data redundancy that causes inconsistent data and system state. SIS, CMS, assessment, exam, and finance information systems need student Data, unfortunately with different formats and different types. Questions like which system should manage this data? Shall every system manage its own data? Shall the system take the risk of having a redundant data? Need to be answered.

Figure 1.12: Redundant Student Data

* + 1. **Functionality Redundancy**

Functionality overlapping and redundancy is clear from the literature review. Functionality redundancy comes from the attempt of LMS software vendors to increase the tasks performed by LMS to include functions that are not part of it. Redundancy is accepted only if it is managed.

1. **Thesis Motivation**

This chapter presented the information systems utilized by educational institutions. They are UMIS and LMS. UMIS serve educational institutions to automate managerial tasks, and LMS provides the required functionalities to automate the learning process. Educational institutions need both UMIS and LMS to satisfy e-Learning and enhance the learning process. Both UMIS and LMS are composed of collection of task specific applications. Educational institutions; and as a result the learning process, can be enhanced by enhancing the information system that serves them. Shortages of current LMS are evaluated in order to find solutions that serve educational institutions to better address information, learning, and functionality requirements.

Service Oriented Architecture (SOA) is one of the software architectures that satisfy most of the non-functional requirements addressed by information systems. SOA principles need to be presented and studied in order to utilize SOA for UMIS and LMS to overcome current LMS shortages, limitations, and deficiencies. SOA as a design pattern is expected to solve many of the current information systems’ problems by easing integration, interoperability, and agility.

The idea of this thesis is to adopt SOA in e-Learning via presenting UMIS and LMS based on SOA, and evaluate the proposed components to determine the efficiency of SOA. Evaluating LMS is not limited by evaluating the architectural style of the system, it shall be expanded to include pedagogical and managerial aspects too.

1. **Thesis Goals**

This thesis attempts to address the shortages of current University Management Systems and Learning Management Systems, specially the gap between the two mentioned information systems, highlighting some of the advantages that can be achieved by integrating both together, and evaluating SOA as the software architecture to integrate both.

Thesis activities and tasks are:

* Surveying e-Learning to determine what e-Learning means, and to formalize the huge differences between what e-Learning means for everyone.
* Studying Enterprise Architectures and Enterprise Non-Functional requirements, the relationship between both, and the capability of Enterprise Architectures to achieve non-functional requirements.
* Surveying Service Oriented Architecture as the software architecture that satisfies mostly all functional and non-functional requirements.
* Proposing the Services based Learning Management System and University Management System, with extended analysis, design, and implementation details.
* Evaluating the implemented Learning Management System and University Management System components.

1. **Thesis Outline**

Thesis includes 6 chapters that are organized as follows

**Chapter 1** Introduces e-Learning, models, acronyms, and defined problems. UMIS, LMS, evaluation of current LMS are addressed.

**Chapter 2** Presents an intensive SOA overview, characteristics and advantages, SOA enablers (like Software agents and Web services), Web services as main SOA enabler, advantages and key features of Web services.

**Chapter 3** Presents the architecture blueprint that will be used for all proposed architectures. Also, presents major UMIS services based components, besides analysis, design, and implementation details. Presented UMIS components are: Student Affairs Management System (SIS), and Library Management System.

**Chapter 4** Introduces LMS components and it is divided into three parts

**Part I** Presents SOA for Digital Library. Digital Library does not refer to automation of library activities and managing it electronically, but it refers to presenting University and Faculty books, research papers, and any other educational material in a digital format and making them available for students and for the rest of applications to integrate, and make use of.

**Part II** Presents SOA based Course Management System (CMS) that address new features and capabilities like searching, importing, and unlocking different course repositories, besides integrating software agents with Web services.

**Part III** Presents an extension to the SOA based LMS that addresses assessment, and the capability to introduce mobile assessment. It presents the experience of providing an online SOA based Assessment Management System (AMS). Students will get their usernames and passwords, log in, target their due assessment, take it, and check the result. Proposed SOA based AMS facilitates interoperability requirements of Mobile Assessment.

**Chapter 5** Presents an evaluation of the proposed UMIS and LMS components against some information system quality characteristics and some pedagogical features. From information system point of view, points like performance, integration and interoperability, compliance, security, maintainability, analyzability, decomposability and modularity, testability, portability via replaceability and scalability, simplicity, modifiability, and reusability are addressed. A Comparative performance analysis is presented to test SOA based systems user-perceived performance against non-SOA based systems. Pedagogically, SOA adoption enhanced the learning process activities and provided capabilities that was hard to present before, like unlocking and sharing course repositories of different LMSs, and M-Learning.

**Chapter 6** Concludes thesis summarizing evaluation results and highlighting information system and pedagogical advantages of adopting SOA in e-Learning.

1. Informative model is the model that forces one way of information transformation from instructor to learner, no matter what personal differences are, instead, learner oriented model modifies the system to fit each individual learner based on personal data, because people are different. [↑](#footnote-ref-2)
2. Learning Management System (LMS) and Virtual Learning Environment (VLE) reflect the same implementation of the same concept. LMS as an acronym is widely used in the United States and was presented in 1980. VLE as an acronym is widely used in United Kingdom and it was presented in 1983 [20]. [↑](#footnote-ref-3)