ENTERPRISE RESOURCE PLANNING (ERP): A VIRTUAL LAB IMPLEMENTATION FOR MANAGERS' AND USERS' TRAINING

by

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Abstract

Enterprise Resource Planning (ERP) systems is the most important business technology up to date, incorporating Information and Communication Technologies (ICTs) with Business Administration best practices, aiming to give strategic advantages to the organization adopting it. But ERP systems are complex with consequence significant problems during ERP implementations. To overcome those problems extensive training is necessary during their entire implementation life cycle. Business Universities are already involved in the ERP training process addressing students, citizens, managers and business employees, an extended audience that demands for a very flexible design of the ERP labs. This paper proposes a Virtual laboratory implementation for ERP training, an implementation that can be also utilized by all types of organizations in order to maximize ICTs integration and minimize computer systems investments.

Keywords: ERP management advantages, ERP implementation problems, Business training, Training architectures JEL M00 (General).

Introduction

The business environment is dramatically changing since globalisation is posing new challenges to the companies such as increasing competition, expanding markets, and rising customer expectations. These new challenges result in ever increasing pressure on companies to lower total costs in the entire value chain, shorten business cycles, drastically reduce inventories, expand product choice, provide more reliable delivery dates and better customer service, improve quality, and efficiently coordinate global demand, supply, and production.

As the business world moves ever closer to a completely collaborative model and competitors upgrade their capabilities, to remain competitive, orga-

nizations must improve their own business practices and procedures, share with their suppliers, distributors, and customers the critical in-house information they once aggressively protected and upgrade their capability to generate and communicate timely and accurate information. To accomplish these objectives, companies are increasingly turning to Enterprise Resource Planning (ERP) systems.

The installation of an ERP system can offer significant competitive advantages to the organization adopting it, but it also incorporates inherent implementation difficulties which may result in significant cost or duration overruns and end-users' frustration. An ERP system is designed in a way that will fit to a variety of different vertical markets (types of business). This is achieved through the extensive use of multiple levels of parameters, which when set properly, can adapt the ERP system to the specific needs of the organization implementing it. This inherent complexity must be overcommed through extensive training.

Business schools have already introduced ERP systems' education and practical training (lab sessions) in their curriculum, responding to a specific business need. The audience is not limited to business students, but it also involves citizens, managers and business employees (participating in a Lifelong Learning course) who want to learn technologies that can be applied immediately to a business environment. This extended audience and the evolvement of e-learning technologies impose specific requirements to the way those lab sessions will be conducted and there is a specific need for attendance from anywhere and at anytime.

The successful implementation of such a full scale remotely accessed lab involves at least three significant parameters (a) the design and physical implementation of a flexible model that will allow remote access to business software, (b) the preparation of supporting material in the form of step-by-step instructions that will help the students perform lab sessions with minimum instructor intervension and (c) design the supporting mechanism that will help local and remote users overcome run time problems.

The scope of this paper is (a) the design and physical implementation of a virtual laboratory model that will allow remote access to all available business laboratory software and (b) to show the significant educational and business advantages of such an implementation. This virtual lab prototype was built and fully tested in real-life lab courses by local laboratory users (physically located in the laboratory area) and also by remote Intranet and Internet users, in

both undergraduate and postgraduate courses at the Business Administration Department of the University of Piraeus.

The findings of this research can be also immediately applied to all types of organizations, since it assists them organize the way computer resources will be distributed in order to maximize ERP and other business software system integration, while at the same time minimize their computer systems investment.

1. Enterprise Resource Planning (ERP) Systems

Experts and practitioners disagree about the role that ERP systems play in corporate management. Some believe that ERP is used to manage the whole business process, however, others believe that ERP works for only the important parts of the business. For example, Gartner Group[1] and Webopedia[2] support the concept that ERP integrates all facets of the business, but Whatis.com[3] indicates that ERP is related to important parts of a business. Moreover, Gartner Group specifically points out that ERP allows all business functions to share a common database and business analysis tools.
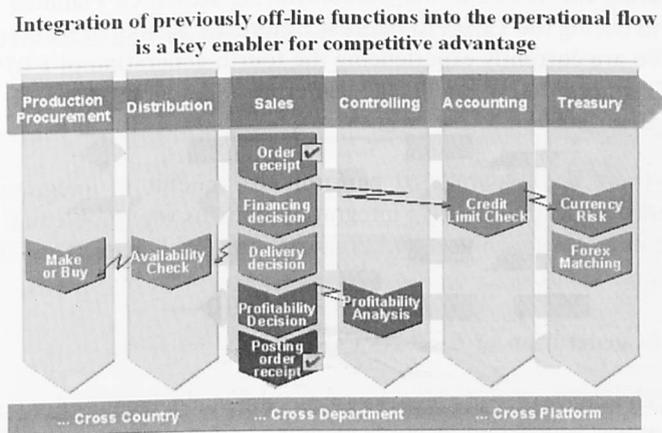

Figure 1. Integration of Enterprise functions under ERP technology

After comparing these perspectives, it is clear that an ERP system is a set of highly integrated applications, which can be used to manage all the business functions (both Value Chain functions, dealing with customers' and suppliers'

relations and all production and distribution activities, as well as Supportive functions) within the organization. Therefore ERP is a commercial software package (utilizing Information and Communication Technologies - ICTs) that promises the seamless integration of all the information flowing throughout the company, including financial, accounting, human resources, supply chain, customer information etc., aiming to offer a unique competitive advantage to the organization using it. A key feature of enterprise integration is business integration, i.e. understanding the way business processes and enterprise policies are structured, how they relate to one another and how they are efficiently executed using the enterprise means (e.g. human resources, applications, and physical resources) depending on the availability of internal or external enterprise objects (e.g. events, information entities, physical entities, etc.) or conditions. ERP systems link all (or many) business functions and operating locations so all have access to relevant information as transactions occur (Figure 1).

ERP systems are based on a mature technology that started during the 1960's with the first Material Requirements Planning (MRP) systems which evolved during the 1970's to the Manufacturing Resource Planning (MRPII) systems and during the 1990's to the first Enterprise Resource Planning (ERP) systems. We are currently experiencing the fourth generation of ERP systems, ERPII (Gartner, 2001) or Total Enterprise Integration (TEI) systems (Langenwalter, 2000).

While, there are unparalleled performance benefits in integrating enterprise systems, achieving effective integration remains very problematic domain due to the numerous technical and organizational challenges (Kumar and van Hillegersberg, 2000).

1.1 The 4th generation of ERP systems

ERP technology offered a new vision for the management of enterprise resources that was centred on resource planning and inventory accuracy and visibility beyond the plant and throughout the manufacturing enterprise, as many industries turned to ERP systems to provide "back-office" financial transaction-processing capability. However, as ERP deployment became less capable of providing competitive advantage, enterprises looked to applications like Supply Chain Management (SCM), Customer Relationship Management (CRM) and, more recently, e-business functions to jump ahead of their competitors.

The vision of the 4th generation of ERP systems (ERP II) addresses the future by focusing on deep industry domain expertise and on conducting interenterprise, not just enterprise, business. For users, ERP II represents a business and application strategy that builds on current ERP deployments and converts the information within the enterprise into a tool for collaboration within communities of interest, through integration that goes beyond the limited boundaries of the enterprise.

ERP II's domain expands beyond ERP to include nonmanufacturing industries. Functions addressed within those industries expand beyond the traditional manufacturing, distribution and financial areas to include traditionally complementary ERP functions such as CRM, Human Resources Management (HRM) or SCM. The Web-centric, designed-to-integrate architectures of ERP II products are so different from ERP architectures as to eventually require complete transformation. ERP II data expands from enterprise-centric ERP data that attempts to store all within the enterprise to data distributed throughout a trading community.

1.2 Characteristics and architecture of ERP systems

Typical architecture of a contemporary ERP System
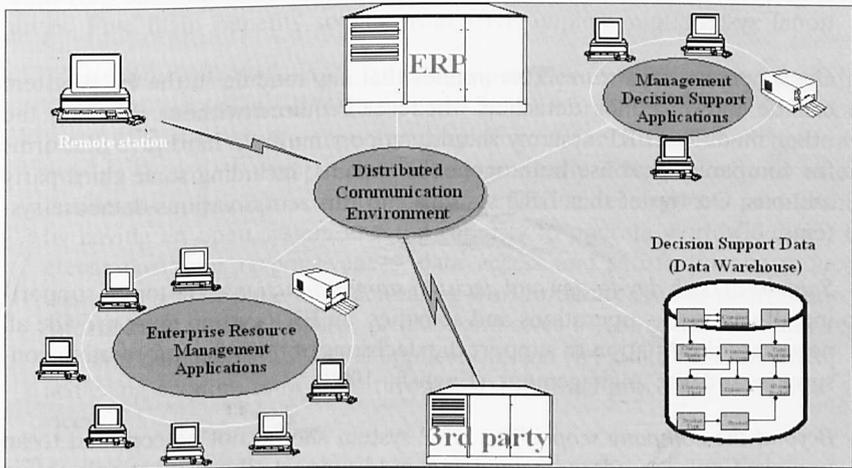

Figure 2. Typical architecture of an ERP system

Usually, ERP systems have the following key characteristics

— *Computer systems distribution*: An ERP system employs client/server technology. Its applications are most commonly deployed in distributed and often widely dispersed manner. While the servers may be centralized, the clients are usually spread to multiple locations throughout the enterprise.

— *Enterprise-wide database*: An ERP system is always implemented via a core database of the system. The database interacts with all the applications in the system, thus, there are no redundancies in the data and its integrity is ensured. Before using ERP, a company was using multiple database systems across business processes with multiple versions of data, and under such circumstances, vital business decisions were usually based on inaccurate and non-normalized data.

— *Applications modules*: ERP vendors provide different kinds of ERP application modules that are integrated software packages for individual business. Most ERP systems start with a set of core modules, and offer additional modules from which a company can choose. ERP systems require users to comply with the processes and procedures as described by the applications. Vendors also offer specialized applications to account for unique processes and procedures within a given industry. The key characteristic of the ERP system of course is the integration of all these modules into one fully functional system.

— *Open system architecture*: This implies that any module in the ERP system can be interfaced or detached whenever required without affecting the other modules. ERP systems should support multiple hardware platforms for companies that use heterogeneous systems, including some third-party add-ons. On top of that ERP systems can run across various database systems.

— *Support of both day-to-day and decision support functions*: On top of supporting all day-to-day operations and activities, an ERP system must provide all necessary information to support the decisions of both the information consumers and the management (English, 1999).

— *Beyond the company scope*: The ERP system should not be confined to an organization's boundary. Instead, it should support all organization's online services to external entities and must be the building block for e-business applications.

1.3 Management advantages of using ERP systems
and implementation problems

An ERP investment is a strategic investment and the returns will be apparent to the organization through the improvements of various Key Performance Indicators (Kaplan and Norton, 1996), only after two to three years of its initial implementation. A recent study (Hunton et al., 2003) examined the longitudinal impact of ERP adoption on firm performance by matching 63 firms with peer firms that had not adopted ERP systems. Results indicate that return on assets (ROA), return on investment (ROI), and asset turnover (ATO) were significantly better over a 3-year period for adopters, as compared to nonadopters. Another significant finding of the study is that the financial performance of nonadopters decreased over time while it held steady for adopters.

These and other business perspective advantages of ERP systems, analysed in this paragraph, have been key motivations for the rapid deployment of ERP over the past ten years.

Most IS success studies have concentrated on technological innovations with limited organizational scope; however, an ERP package is perhaps one of the most inclusive technologies in organizations thus far. ERP provides the enterprise-wide solution to deliver many benefits such as low operating costs and improved customer service, thus enhances their business operations in many areas. Five main benefits sought from ERP implementation are:

— *Competitive advantage.* An ERP system provides the opportunity, the infrastructure and advanced ICTs that will help an organization: (i) Gain competitive business advantage by preparing it for future challenges and helping it remain competitive, (ii) Dynamically adapt, grow and extend businesses and adopt new business strategies or develop new partnerships by having an open system and the capacity to operate worldwide, (iii) Increase customer responsiveness, data access and satisfaction by reducing customer service time and facilitating worldwide access and distribution of information about company, product and sales by using the customer relationship management (CRM) application, and (iv) Build cost leadership by achieving economies-of-scale through streamlined processes or shared services.

— *Globalisation.* ERP allows for the flexible use of language (while at the same time it utilizes a uniform user interface), currency, and accounting standards. It thus improves adaptation to globalisation and global market

development. Globalisation enables organizations to operate in the world-wide market, provide equivalent levels of service to customers worldwide, overcome the problem of information fragmentation, and improve information flow to and from customers, suppliers and business partners. Once achieved, e-commerce and e-business become possible through ERPII applications (Gartner, 2001) such as supply-chain management (SCM), online procurement, and Customer Relationship Management (CRM).

— *Integration and Standardization.* ERP brings the benefit of full business processes integration and standardization. Integrated ERP packages can satisfy most application needs of various organizations. This integration results (i) in the automatic update of data among different business components and functions and (ii) in real time filing and data analysis from a variety of sources. This has eliminated integration complexities associated with applications from multiple-vendors and has enhanced information flow among internal processes. That way of communication and integration among different business processes are improved, data are managed in a more comprehensive and unified way and process and data integration and standardization is business-wide. An integrated and centralized system has provided support for complete data visibility for all levels of organizational management, thereby facilitating corporate and strategic decision-making.

— *Best practice/business processes.* Business process is defined as "a set of logically related tasks performed to achieve a defined business outcome" (Davenport and Short, 1990). ERP serves as a more controlled and more coherent contact point among the internal business units, regardless of geographical separation, and has improved the overall business processes and practices (Davenport, 1999). This has also facilitated improved business performance and shortened product cycle times.

— *Cost reductions - improved effectiveness.* The characteristics of real-time, single and centralized database, and the availability of maintenance support from the vendor have allowed: (i) Operational cost reduction, for example reduction in time and cost associated with order re-entry errors, data entry, wrong shipment and administrative burden for the sales force, (ii) Savings in integration expenses for different applications from different vendors, (iii) Shortened cycle times and reduced inventories and (iv) Lower maintenance cost, as the cost is spread over many other users.

Although ERP systems exhibit considerable business advantages, the implementation of a large ERP system requires not only substantial time and effort,

but also a wide range of expertise and knowledge (besides knowledge of existing business processes) on the functional aspects of the package, system configuration and system integration, technical knowledge of the related hardware and software, project management and change management, managing knowledge transfer, and organizing system users' training. ERP-adopting organizations typically lack this expertise and usually outsource these activities to the ERP vendor, hardware vendor, and consulting firms (Sumner, 1999).

According to a Standish Group research on ERP implementations, more than 1/3 of ERP projects are cancelled and only 10% of all projects are completed on time and on budget (Figure 3).
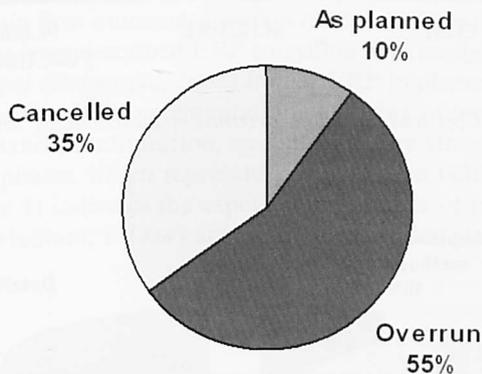

Figure 3. ERP successes and failures

When the 55% of ERP projects overrun are further examined, the average cost overrun (over-budget) is 178%, the average schedule overrun is 230% and the average functionality achieved is only 41% of the functionality planned (Figure 4).

When the causes of these failures, overruns and inability to meet users' expectations are further examined, only 5% are due to the wrong selection of ERP provider and only 10% are due to the implementation methodology. The remaining 85% of causes have to do with the organization's specifications (lack of detailed business processes specifications 25% and their ERP system implementation 30%) and the balance of roles (30%) of the parties involved (Figure 5).
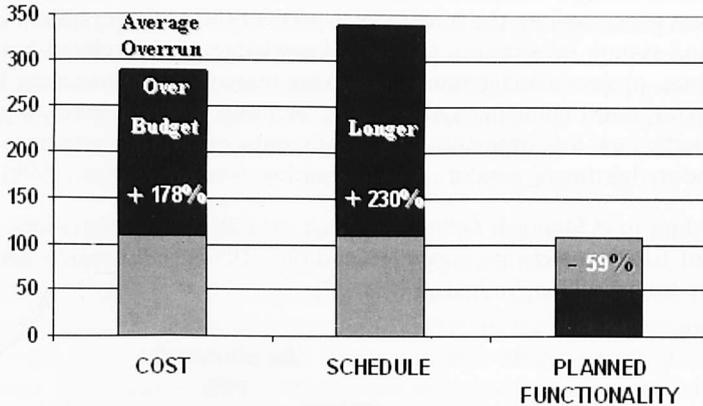
Figure 4. Cost and Schedule overruns – Functionality under-runs
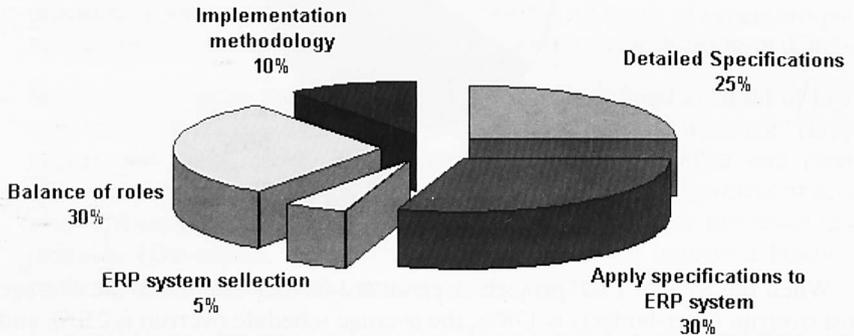

Figure 5. Causes of ERP failures and overruns

1.4 Implementation success factors for management

A number of factors that affect the implementation process and the probability of conversion success have been identified in the literature (Lucas, 2000). The study of ERP systems and the factors that impact their success have been

the subject of empirical investigation. Success factors identified in the literature include support and commitment of senior management, redesign of business processes to fit the software, investment in user training, avoidance of customization, use of business analysts and consultants with both business knowledge and technology knowledge, integration of ERP systems with other business IS, and ability to build key in-house IT capabilities (Sumner, 1999). A review of the nonacademic literature suggests other important factors, such as careful software and vendor selection, standardization, transition planning and data conversion, upfront business changes, and ongoing vendor support.

While a factors view identifies which issues are critical to the implementation process, a process approach sees implementations as a sequence of stages and seeks to explain how outcomes develop over time (Boudreau and Robey, 1999). Researchers have described ERP transition with models having three to six stages. Rajagopal (Rajagopal, 2002) frames ERP implementations in terms of the six-stage model of IT implementation consisting of initiation, adoption, adaptation, acceptance, routinization, and infusion, the strength of this model is in the last two phases, which represent post-adoption behaviour. The table that follows (Table 1) indicates the expected importance of players and activities (H-High, M-Medium, L-Low) across implementation stages (Somers and Nelson, 2004).

TABLE 1

ERP players' and activities' importance per implementation stage

		ERP Implementation Stages					
	Players (P) and Activities (A)	Initia-tion	Ado-ption	Ada-ptation	Acce-ptance	Routi-nization	Infu-sion
P	Top Management	H	H	H	H	H	H
P	The project champion	H	H	H	H	M	M
P	The steering committee	H	H	H	H	L	L
P	Implementation consultants	H	H	H	M	L	L
P	The project team	H	H	H	H	L	L
P	Vendor-customer partnership	H	H	H	H	M	L

(continues)

P	Vendor's customization tools	L	H	H	L	L	L
P	Vendor support	L	L	L	M	H	H
A	User training and education	H	H	H	H	M	L
A	Management of expectations	H	H	H	H	M	L
A	Careful package selection	H	H	L	L	L	L
A	Project management	H	H	H	H	M	L
A	Customization	H	H	H	L	L	L
A	Data analysis and conversion	H	H	H	M	L	L
A	Business process reengineering	H	H	H	M	L	L
A	Architecture choices	H	H	M	L	L	L
A	Dedicating resources	H	H	H	H	M	L
A	Change management	L	H	H	H	M	L
A	Clear goals and objectives	H	H	H	H	H	H
A	Education on new business processes	L	H	H	H	M	L
A	Interdepartmental communication	H	H	H	H	M	L
A	Interdepartmental cooperation	H	H	H	H	M	L

1.5 Why are ERP systems considered to be complex

A common theme in ERP literature is the inherent complexity of ERP systems (Bingi et al, 1999). Complexity is the degree to which a certain innovation is difficult to understand and use. It is the opposite of ease of use or the degree to which a particular system is perceived to be relatively free from physical and mental effort (Davis, 1989). Companies that perceive their adopted ERP system to be a complex business solution will tend to diffuse it slowly and in limited capacity, thus not realizing its full benefits. It is also suggested that the perceived complexity of an innovation leads to resistance due to lack of skills and knowledge. This resistance to new technologies leads to lower satisfaction and system performance. Based on these rationales, the following hypothesis is postulated: The perceived degree of complexity of ERP systems will have a negative relationship with implementation success.

1.5.1 ERP systems parameterization (optionality levels)

The alternative options provided by an ERP system appear in different levels of application or optionality levels. Capturing the entire scope of options supported by the ERP system in a model is a challenging and complex task, which is essential for identifying a good solution for the enterprise needs. The ERP options enable adapting the system to various enterprises with different needs, and are controlled by a set of parameters, whose values are determined through an alignment process.

Three levels of optionality are distinguished (Soffer et al., 2003) as: System Configuration level, Object level, and Occurrence level

— The System Configuration optionality level affects the functionality of the ERP system throughout the entire system. The various options are controlled by the system parameters, whose values are set once when the system is implemented in an enterprise and remain static thereafter.

— The Object level is an intermediate optionality level, controlled by the parameters of single data objects, and can vary in different instances. Different parameter values cause different instances to be handled in a different manner.

— The Occurrence level, which is the lowest level of optionality, applies to a single occurrence of a process, and facilitates variance in its performance or run time behaviour of the system (the user sets parameters at run time).

The entire customization activity, which is vital to the compliance of the ERP system to business internal processes of the various functions such as design, production, purchasing, marketing, and finance, is conducted through parameterization (setting values of parameters) at the system configuration and the object level. Modification of parameters results in different behaviour of the ERP system. Therefore an excellent knowledge of all available options per parameter and all possible interactions between parameters is a necessary precondition for a successful ERP customization in order to satisfy most business specific needs. If there are customization problems the system will either not function as expected or will not function efficiently.

Occurrence level parameters allow the end-user to adapt system behaviour in order to satisfy specific business needs by modifying run-time parameters. Again if the run-time parameters are not set properly the system will either not function as expected or will not function efficiently.

From the above it is obvious that ERP systems' parameterization (optionality) which is one of the biggest advantages of ERP technologies, since it allows system adaptation to satisfy specific business needs, can be considered a major drawback if either the project team or the end users cannot understand its functionality. This is usually why ERP systems are considered to be complex and this is why extensive training is critical during all stages of an ERP system implementation life cycle (Bingi et al, 1999).

2. Training for managers and organizations

The role of training to facilitate software implementation is well documented in the MIS literature (Nelson and Cheney, 1987). Lack of managers' and users' training and failure to understand how enterprise applications change business processes, frequently appear to be responsible for many problematic ERP implementations and failures. Education/training is probably the most widely recognized critical success factor, because managers' and users' understanding and acceptance is essential. ERP implementations require a critical mass of knowledge to enable people solve problems within the framework of the system. If the employees do not understand how a system works, they will invent their own processes using those parts of the system they are able to manipulate (Laughlin, 1999).

One of the greatest advantages of ERP, integration of data, can also be a major problem when errors are introduced into the system. An error upstream can instantly impact what people do further down the line; therefore, employees should be aware of the problems their mistakes can cause (Stedman, 1998).

The full benefits of ERP systems cannot be realized until managers and end users are using the new system properly. To make training successful, the training should start early; preferably well before the implementation begins. Executives often dramatically underestimate the level of education and training necessary to implement an ERP system as well as the associated costs. Top management must be fully committed to spend adequate money on education and training and incorporate it as part of the ERP budget. It has been suggested that reserving 10-15% of the total ERP implementation budget for training will give an organization an 80% chance of implementation success (Maxwell, 1999).

All too often, employees are expected to be able to effectively use the new system based only on education and training. Yet, much of the learning process comes from hands-on use under normal operating conditions. Com-

puter-based training via Intranets has been found to facilitate ERP implementations (Mahapatra and Lai, 1998).

From paragraph 1.5 above it became apparent that two levels of ERP training are required if a user must take full advantage of the capabilities of an ERP package: (a) ERP parameterisation (optionality) training and (b) end-user training. ERP suppliers organize such training sessions either in class or through e-learning. For the needs of professional training specific business cases have been built that exhibit in practice the main features of the ERP system.

2.1 University training as a case of implementation

A recent European Union (EU) research (SEUSSIS, 2003) indicates that EU employers expect universities to keep ahead of changes in the Information and Communication Technologies (ICT) marketplace, predict the ICT skill sets that graduates will need over the next ten years and include technologies like ERP in their student training. That way students will be able (a) to use technologies that organizations already use and (b) help employers formulate their future ICT needs.

To prepare a business case for students is different than preparing a business case for professionals. Both students and professionals do not know how to use a specific software tool. But a professional is usually aware of the business environment (domain knowledge) and he/she lacks the specific knowledge of how to apply a technology in order to solve a known business problem, whereas a student doesn't clearly understand the business environment. On top of that a group of students present strong differentiations amongst them and heterogeneity in their characteristics (Soloway et al., 1994).

Therefore a case study designed by a software tool vendor in order to train professionals in the use of a specific tool, might be inappropriate when used to educate and train university students. For that reason new business cases should be developed to educate and train students. The same business cases can be used in the Lifelong Learning process to educate and train citizens and business employees.

For the needs of ERP training the design and development of a business computer laboratory is a necessary must, that will enhance the skilfulness of the students, in order to further support their personnal, social and professional evolution in the knowledge-based globalized economy.

Those ERP laboratories should be designed in a way that will make them available to (a) local laboratory users (physically located in the laboratory area), (b) remote Intranet users (located anywhere in the University Intranet), (c) remote Internet users and (d) remote lab users (remote labs located in another University or Training Center). This way synchronous lab sessions designed for local University lab students can be available for any e-Learning and Lifelong Learning setup, either in a formal lab session (local or remote), with the presence of an instructor, or in an informal setup where the student or the citizen or business employee (participating in a Lifelong Learning course) can perform lab sessions from anywhere and at anytime.

3. Critical implementation factors and virtual lab implementations

As the scope of the virtual lab prototype is to solve real educational and training needs, before the actual implementation various factors were considered such as

1. Implementation factors about a state-of-the-art computer laboratory

2. Existing virtual lab implementations at various universities worldwide

The findings of this research are presented in this section. The factors discovered were considered during the design and the actual implementation of the virtual laboratory, the business case studies and the proposals for further development of the model.

3.1 System architecture

One basic finding that comes from most sources examined is the need for an open system that will be open both to the University environment and to the outside world.

The system should be open to students for local in-campus training but also wherever there is access to the Internet, in a Distance Learning set-up. It should also be available to citizens and business employees in order to help them satisfy their Lifelong learning needs, through formal and informal education and training settings (SEUSSIS, 2003).

The main design idea of the system should be that of a virtual laboratory that uses the Web as the communication structure and have a flexible ICT architecture (Kam et al., 2002).

3.2 Implementation considerations

An ERP computer laboratory does not involve one single computer application and ICT technology. It involves Business Applications (both Value-Chain and Supporting applications) to help the students understand the various business functions, interrelationships and data flows amongst them, Workflow Applications to help them understand how the Organizational Structure integrates with Business Contents (documents, databases, files etc.) and Business Rules, Business Intelligence Applications to help them understand how day-to-day processes and data are transformed into information that helps information workers in their decision making process etc. Therefore each cluster of applications consists of many different applications and technologies, each of which might demand for a long period of faculty's and technicians' on the field training, in order to be able to design and support business scenarios that will give to the students the overall picture per technology and help them understand its philosophy, so that they will be able to solve real-life business problems using it. The integration of so many technologies can be a very demanding multi-year project in terms of faculty resources.

This calls for an efficient allocation of resources (infrastructure, faculty and technical personnel) and a support group of specialists per university, plus a feasible long-term implementation plan that will allow for a step-by-step realization.

In a small country like Greece with limited budget for infrastructure and personnel resources, the design and implementation of an integrated environment to support education and training on various clusters of applications and technologies, demands for a national-sized project that must also involve the industry (software companies specializing in specific market sectors).

When designing the environment, two costs should be considered for infrastructure, personnel and third parties:

➤ Implementation costs and

➤ Support – running costs.

4. The prototype

4.1 The client/server model

Every online software program manipulates application and user data, based on its logic and uses a computer-user interface (presentation) to help the

user communicate with the software. The presentation is always on the client (at the user's side). The data and application logic can be either on the client, on the server, or distributed between the client and the server. This distribution of data and logic is the underlying idea of the client/server model.

Figure 6 presents schematically all possible alternatives of software distribution between the server (top) and the client (bottom), giving the corresponding terminology per alternative. When both data and logic reside on the server, then the client is either a terminal, or a thin client. In a thin client mode of operation, logic is distributed between the client and the server. In a fat client mode of operation, logic resides on the client and data is either on the server side or distributed between the client and the server. Finally in a standalone mode both data and logic reside on the client (Macris, 2001).
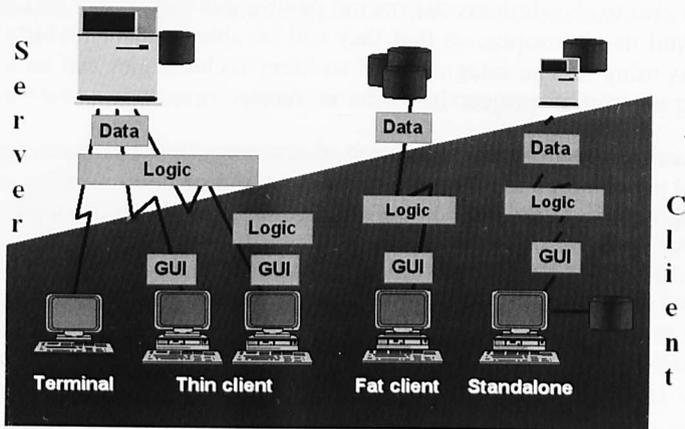

Figure 6. Client/Server modes of Software distribution

University of Piraeus and most Greek Universities' business laboratories use the standalone model when running local applications (e.g. office applications, or statistical applications) and the thin client model when connected to the Internet. The majority of ERP installations in Greece that do not run over the Web, use the fat client model where data is installed on a database server and the majority of programs must be installed on each client utilizing the system.

This policy results in the need for (a) continuous upgrade of the ERP client computers in order to be able to run more demanding (in terms of computer resources) software and (b) installation of operating systems and all local programs per client.

On top of that, both the standalone and the fat client modes demand from each client for (a) powerful hardware and specific software resources (Operating System and Utilities) and (b) local installation on every remote client of all application software needed.

4.2 The prototype virtual laboratory

ERP sytems are server based and this is the underlying theory behind them, which is to share information amongst many users (Callaway, 1999). Some ERP systems can be accessed through an Internet browser, some need a fat client mode of operation (all application programs should be installed and updated on the client).

As stated in paragraph 2 above, before being able to use an ERP system for day-to-day operation, a lot of company specific data (parameters) should be entered. Many ERP systems that can be accessed through a browser for day-to-day operation also need a fat client (windows client) for the parameterisation (optionality) process.

As a conclusion the infrastructure needed for an ERP lab and most Client/Server based applications is

a) A powerful database server

b) LAN (Local Area Network) connecting the server and the clients and

c) Powerful clients.

This set-up is difficult to implement when there are hundreds of students (or citizens - business employees) wishing to access the applications, each of which being located in a different place and with varying local computer (client) resources. Additionally the software set-up process, if there are many applications to be installed (which is the case with ERP software), can be very demanding and error prone.

One additional problem, at the University of Piraeus, was that the specific ERP application chosen (from a local software house) needed local client resources (mainly in terms of local memory), which were unavailable.

The solution chosen was to shift from the fat client model to the thin client model (presentation only on the client side). The server-side software utility used in order to be able to realize the thin client model on a Microsoft Windows Server, is Microsoft Windows Terminal Server ™ (there is also third party software available for this purpose). The installation on each client (client access) is minimal (can be done over the Local Area Network - LAN). All the software runs on the server and the client are only used as a terminal to the server. Therefore the server acts as a database and application server for the ERP application and as a terminal server (serving the remote clients) (Macris, 2001).

This model can be used for any application, which when installed on the server, can be readily accessed and run by any remote client that has permission to access the server, either through the local LAN or through the Internet.

This way the local clients on top of all software installed locally can also run remotely all the software installed on the server, as though each client has installed locally all the software installed on the server (augmented lab). The same applies to any computer accessing the server through the local LAN or the Internet (virtual lab).

After the successful implementation and testing on two undergraduate (ERP based) courses of the virtual lab concept, new applications were introduced for student training, a BI application (as BI - Business Intelligence technology is complementary to ERP, since it mainly uses ERP data) and DM (Document Management) since EDCM (Electronic Document and Content Management) is an emerging technology utilising both structured ERP data and unstructured electronic media (documents, spreadsheets, presentations, e-mails, etc.).

The installation of the BI tool took place on the existing server, using the same architecture. The DM tool was installed on a new server, in order to avoid overloading the existing server. All client components of the DM tool were installed on the existing server.

The training material involves both end-user and system administration training, because students, citizens and business employees should not only be involved in the training process as end-users, since this would give them a limited understanding of the capabilities of each software. Instead their involvement in the administration process is necessary in order to satisfy the requirement for an overall understanding of all processes needed to complete a task using the software (SEUSSIS, 2003). By going deeper in the underlying philos-

ophy of each software the trainee understands better its capabilities and is therefore more competent to use it in order to solve a specific business problem, since learning is not a process of merely transmitting information from someone who knows to someone who does not. Instead learning is an active process that happens through direct experience, by being engaged in authentic tasks (Soloway, 1996).

The new set-up was implemented and tested successfully in one undergraduate and one postgraduate course. Student access was mainly through the local lab clients. The remote access model (over the Internet/Intranet) was also successfully tested (both using the local LAN and the web), but not fully integrated in the training process because a different support set-up is needed (both in supporting material and run-time support) when a trainee is called to perform a lab session without the physical presence of the trainer to assist him/her overcome the run-time problems.

4.3 Business advantages of the proposed virtual lab implementation

Summarising, the advantages of the virtual lab approach are

Typical client/server implementation	Proposed virtual lab implementation
Increased cost of upgrade for client computer hardware and operating and application software	No need to upgrade clients. Even old clients with minimum resources can be used as terminals
Increased cost of support due to software installation and re-installation (if there is a problem with a client)	The client access software is installed once per client and this is the only requirement.
Unstable environment for the trainer or the support personnel as the state of each client is not known before the ERP session, when many lab sessions using a variety of software take place during the week (is the software installed? are the specific examples needed for the session installed? etc.).	The trainer or the support personnel do not need to have access to all remote clients but only to the terminal server. So a modification at the server will be automatically available to all clients accessing it.
The trainer or the support personnel cannot test the ERP environment from a different location (e.g. his/her office or home through the Internet) but only by being physically in front of each client computer.	The trainer or the support personnel can have access, through the terminal server, to the same environment as each remote client accessing it.

(continues)

The ERP user cannot use the software outside the offices and he/she cannot repeat the ERP session in another computer (at home or in a different location), because it is difficult to install all software and reconstruct locally the ERP environment.	All clients that have the right to access the server can have access to the ERP system and all other applications installed on the server from any location around the world, as long as there is a network connection (intranet/internet).
The processing power of each client is limited to the local computer capabilities.	On top of the processing power of the local computer, a client when connected as a terminal to the server utilizes all the processing power of the server.
When used for training the set-up can only be used for local format training.	The virtual lab set-up can be used for remote and informal training from students, citizens and business employees in the Lifelong Learning Process (EU, 2003).

4.4 The Inter-University virtual lab model

In order to support the educational and training needs of the trainees involved in the virtual ERP laboratory and help them get an overall picture of the capabilities of ERP systems and how they can help a business organization control its day-to-day operations and enhance its decision making process, extensive business case studies were built.

Those business cases can be collected and installed on remote Case Servers where they can be accessed by many educational institutions, departments and business organizations using the virtual lab concept (Figure 7). This proposed configuration might also involve the software industry that has been willing (at least in the local market) to help the Universities include ERP and other business applications in the University curriculum.

Except for the advantages because of the distribution of effort, the Inter-University model of virtual labs, presents (on top of the other advantages of the virtual lab approach) significant economies of scale both in the implementation (initial costs) and the support (support - running costs) of hardware (servers), software (licenses - support) and personnel involved.

5. Conclusions and management implications

The virtual lab concept can be used efficiently and effectively in order to host ERP and other server based software tools in the process of training both in a Practical (a computer laboratory where trainees work individually and in small teams) and in a Real-life (where trainees solve real-life or nearly real-life problems in the computer laboratory) learning approaches (ICF, 2000) or a
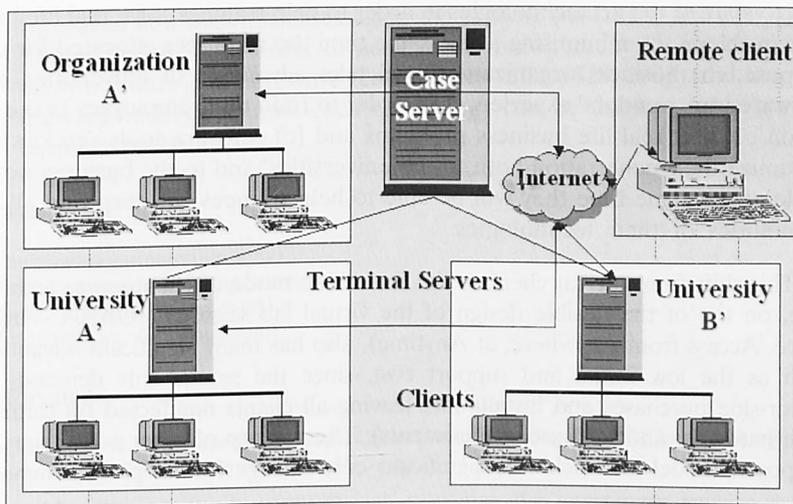
Figure 7. Inter-University Virtual Lab model

combination of the two. This training approach has significant advantages both from the universities' and the businesses' point of view, since trainees involved in the solution of authentic and business real-life problems, will be a valuable asset of business organizations who need employees capable of solving business problems using state of the art technologies.

The trainee access can be from anywhere there is a computer and a communication link to the Internet or to the same LAN with the virtual lab, therefore allowing for physical or virtual lab sessions both in formal and informal lab set-ups (as long as there is the appropriate supporting material and run-time support). The same set-up can be used both for educating and training students, citizens and business employees in the Lifelong Learning process. This flexible approach to business training (EU, 2003) can help trainees manage their time efficiently without the need for extensive out of work training.

The Inter-University model can extend the virtual lab concept and accommodate clusters of similar courses using the same case studies. This model can be implemented by bringing together many universities, departments, business organizations and the local software tools vendors. The advantages of this set-up are considerable for all parties involved: (a) the universities will have ac-

cess to state of the art technologies in order to help trainees solve real life business problems, by minimising at the same time the resources allocated for that purpose, (b) business organizations will take advantage of universities' and software tools vendors' experiences in order to train their employees in the solution of their real-life business problems and (c) software tools vendors will maximize their penetration both to the universities' and to the business world, while at the same time they will be able to help trainees get deep into all the capabilities of their technologies.

This shift from the fat client to the thin client mode of client/server architecture, on top of the flexible design of the virtual lab sessions (IOAAA - Install Once, Access from Anywhere, at Anytime), also has many significant advantages such as the low initial and support cost, since the set-up only demands for server-side purchases and installation, leaving all clients unaffected (in terms of both hardware and software requirements). Thus on top of other advantages the proposed model also achieves significant cost savings for all parties involved:

(a) universities will have minimal initial and run-time costs, since they will share all investments involved with other universities, tools vendors and possibly business organizations,

(b) business organizations through flexible access to the educational material from any client with minimal resources, while at the same time minimizing personnel absenteeism for training and

(c) software tools vendors will minimize the utilization of their resources, since they will be shared by many universities and business organizations having access to the business case servers.

5.1 Further research and development issues

The prototype can be further expanded in three directions

a) Using the business cases implemented with the three environments (ERP, BI and DM) and the virtual lab set-up on a distance learning synchronous lab set-up. This involves two main tasks (a) improve the lab instructions in order to minimize the need for trainer intervention and (b) provide the means to assist the trainers overcome run-time problems

b) Expand the size and the uses of the concept in order to be able (a) to support a bigger number of concurrent trainees and (b) to introduce other lab courses in other disciplines that can take advantage of the virtual lab set-up.

c) Introduce new business cases using the existing (installed) and new applications and ICTs in order to achieve the requirement for integration of many software and hardware technologies (SEUSSIS, 2003) and help the trainees understand how each technology can be used to solve specific business problems.

Notes

1. (http://www.gartnergroup.com/)
2. (http://www.manufacturingsystems.com)
3. (http://whatis.techtarget.com)
4. http://www.standishgroup.com)

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