PREREQUISITES AND DEVELOPMENT STRATEGY FOR SUSTAINABLE E-LEARNING PROJECTS

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ABSTRACT

In this paper we summarize on-going research on prerequisites for successful e-learning projects, establish best practices and risks to avoid, describe a maturity strategy, provide ideas for capacity planning models (human and technological) and cost modeling for economic analysis.

KEYWORDS

e-learning, sustainability, maturity strategy, cost modeling, capacity planning

1. INTRODUCTION

The adoption of information technology in all countries around the world has gained momentum as governments understand the strategic importance of being part of the information society. Governments, enterprises and private individuals expend important amounts of money and effort in order no to be left behind. This trend has fueled the information technology industry, creating jobs and bolstering the GNP of many countries.

It is well known that almost every activity of our society has felt the transformation power of information technology: government, education, health and economy all present different challenges for IT adoption and thus are striving with different methodologies, goals and projects. Unfortunately, there is a high level of attrition as many projects have failed, either by not attaining the stated objectives at all, by providing poor quality of service of simply not offering enough services to justify all the expense.

E-learning projects are especially vulnerable since it is common that they stretch already hard pressed budgets. In this paper we discuss conditions, requisites and methodologies developed by the E-LANE consortium that ensure success of IT projects. Although they were developed for e-learning projects, it will readily be apparent that the principles apply to all e-society types of projects.

E-LANE is a consortium that aims to reduce the digital divide in Latin American countries by developing an education program that uses advanced teaching methodologies and paradigms, as well as open source telecommunications and information technologies (E-LANE means Europe Latin-American New Education).

E-LANE is constituted by educational institutions from both Europe and Latin America, which together have the following goals:

- To develop pedagogical models that will allow the creation of educational programs that can adapt to different needs, environments and audiences
- To develop high-quality, low-cost distance-learning technology such as learning management systems, courseware integration tools and learning evaluation platforms
- To develop effective course, activity and evaluation design methodologies that will allow efficient learning as well as long-term retention of knowledge, abilities, competencies and skills
- To develop innovative courseware design guides and establish readily-applicable criteria which will allow the integration of technology, courseware and activities in different ways for different audiences and environments in order to enhance learning
- To establish sustainability and dissemination principles to achieve all potential impact to society and ensure continuity after the project ends.

In order to achieve those objectives, the E-LANE consortium has chosen the information technology mediated distance learning technology. This technology combines the large audience and large geographical coverage of traditional tele-education with the advantages of computer based learning, such as multimedia resources, and improved navigation, visualization and interaction.

In order to showcase E-LANE's methodologies, technologies and practices several demonstration projects were established in different countries in Latin America in which different targets were aimed, from rural indigenous peoples to urban-university educated populations. A few of those projects are:

- Education of commercial and health practices for ethnic guambian peoples in Cauca, Colombia
- Master degree courses for professionals in Guatemala, Guatemala
- Digital literacy training for government employees in Monterrey, Mexico
- General public digital literacy in Santiago, Chile.

In this paper we discuss specifically sustainability, that is, the ability to extract long-term benefits from resource investment in e-learning projects.

The rest of the paper is organized as follows. In section 2.1 we estate the three rules of sustainable IT projects. In section 2.2 we discuss the maturity strategy. In section 2.3 we discuss human resource formation. In section 2.4 we discuss IT capacity planning, while in section 2.5 we present a cost model for IT projects. Finally, we discuss our conclusions in section 3.

2. SUSTAINABILITY: RESOURCES AND PLANNING

We start off by stating what sustainability means for us: "A characteristic of a process or state that can be maintained indefinitely". In order words, a sustainable e-learning project is one in which either a proper supply of funds is ensured by a government or private entity by a declared expense budget or one in which a steady supply of funds is ensured by providing services that satisfy some economic model. In either case, it goes without saying that the amount of funds allocated should be enough to provide service with adequate levels of quality.

Thus in order to be successful and thus sustainable, every e-society project must depend on three supports (based on [1][1]):

1. Human Resources

[1] Other supports include incentives, compromises and alliances

2. Processes
3. Technology

So the first risk that an e-learning program will face is to focus on one or two of the three supports. The failure to either establish a proper training program, an environment oriented educational process redesign or an integrated high-quality-of-service (QoS) technology architecture will almost certainly translate into failure or no sustainability for the project. There are more than enough documented cases that prove it.

- In many cases, computers and software are acquired at great expense and just dropped off on the organizations that are supposed to go digital. It is not unusual to find out months later that the computers are used just to play solitaire or at most as sophisticated typing machines. We have seen this in municipalities and schools alike.
- Mexico's program for fighting the digital divide "e-Mexico", which consists of government sponsored internet cafes, called "Digital Community Centers" has, by some people, been deemed a failure mainly for the lack clear operational processes and budget specifications [2].
- "Enciclomedia", Mexico's program of educational technology has also been criticized, this time by the teachers themselves, because the extreme expense that the government has incurred has not been as fruitful for it was not followed neither by a thorough training program nor by a change in the learning processes involved [2]

Thus, a sustainable e-learning project will start as a set of planed actions whose objectives are to develop technology, redesign educational processes and prepare faculty and auxiliary personnel for new learning environments such as Internet enabled learning. We will discuss further each of this supports in section 2.2, but in the next section we will discuss how these supports within the e-learning organization relate with the real world outside the organization.

2.1 Three Rules for Sustainability

Even the most scientifically designed e-learning project correctly addressing the issues of human resource, learning processes and technology can fail if real-world issues, such as failing managerial support, bad knowledge management or improper organization are not addressed. Therefore, the three rules for sustainability are simply:

1. Understand the risk factors and avoid them
2. Understand the best practices and apply them
3. Understand the resources and effort required. Acquire all necessary resources, prepare for the required effort.

Although these rules seem obvious, it is surprising how many e-learning projects ignore these simple rules.

2.1.1 Risk Factors

Risk factors for e-learning projects have been documented and are not all that different from other IT projects. These include:

- Failure to get upper managerial support
- Failure to provide enough services
- Failure to provide sufficient quality of service
- Failure to establish a comprehensive training program
- Failure to integrate technology using an enterprise architecture
- Failure to identify all environmental variables and optimize educational process
- Failure to establish the figure of enterprise CIO (Chief Information Officer)
- Failure to define the boundaries between consulting councils and operational staff

- Failure to establish a correct knowledge management process

2.1.1 Best Practices

In contrast, best practices include:

- Clearly define project objectives
- Establish a governing body
- Establish academic as well as administrative and technology councils
- Establish agreed upon, by all those involved at the highest level, written compromises and commitments.
- Establish an incentives program
- Establish profitable alliances
- Get a high-level champion

2.1.3 Resources

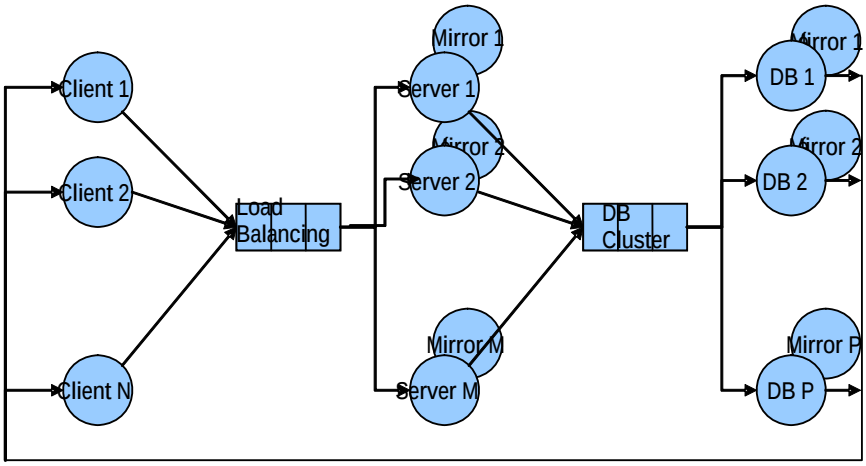
On of the most observed problems is the failure of many projects to understand the resources needed and the amount of effort that people and organizational change for information society projects requires. People need to be trained in new educational technologies, new educational and learning process must be adopted and technology has to be updated while at the same time render adequate quality of service. All that change requires work and money.

The work translates into research, training programs, process redesign programs, equipment and software procurement and configuration, planning and controlling. We will cover the effort required in section 2.2, while dealing with maturity strategies and project planning.

Project costs are much harder to compute. The main problems are that sometimes there is no clear understanding of the required human resources and that there isn't really a reliable model for IT capacity planning. Thus big e-learning projects, those involving thousands of students and teachers (as all e-learning projects should), do not have the tools to adequately determine the necessary hardware and software resources. And if hardware resources cannot be estimated, cost projects will become less accurate.

In order to ensure high availability, high reliability, high scalability, high performance and high security we propose the IT architecture shown in Fig. 1 [3, 4, 5].

Figure 1. IT Architecture

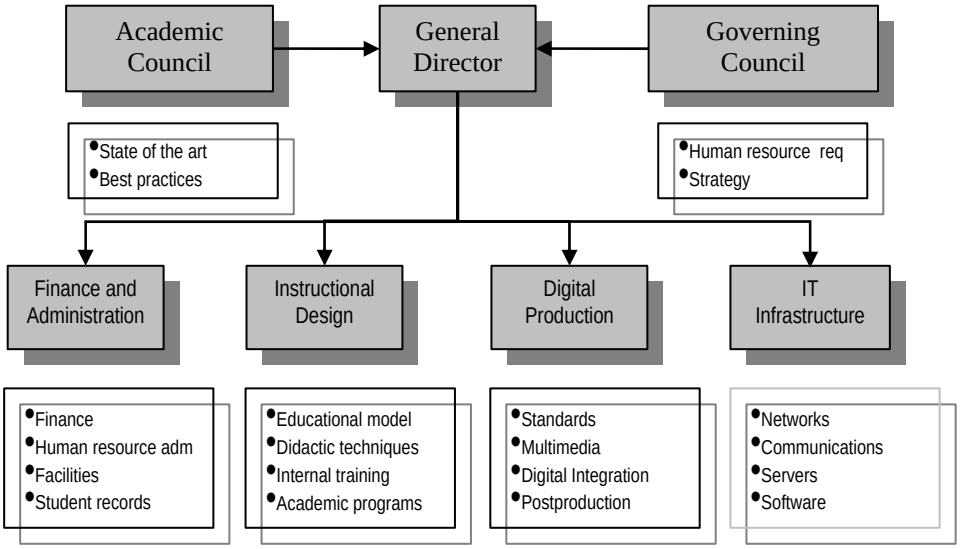


The IT architecture shown in Fig. 1 has been implemented using open source components, hence it has a low acquisition cost (DB means data base). This architecture supports the learning environment which is dotLRN, a very popular learning management system (LMS).

As most IT projects split costs about evenly between software/hardware procurement, consulting/process redesign and training, human and IT resource planning are essential for total cost of ownership analysis (TCO). We will discuss IT capacity planning in section 2.4 and cost analysis in section 2.5.

In the area of human resources, Fig. 2 shows e-learning related functional work areas that must be present in any organization embarking in such projects.

Figure 2. Main functional areas of an e-learning organization



In Fig. 2, in white squares bellow each functional area is a brief description of the activities carried out by each one. Also, in each functional area different people would be responsible of different activities. A list of e-learning related functions and the corresponding area of responsibility is shown in Table 1.

Table 1. Work responsibilities and corresponding functional areas

Function	Area
Academic Program Coordinator	Finance and Administration
Instructor	Instructional Design
Tutor	Instructional Design
Content Specialist	Instructional Design / Digital Production
Content Developer	Digital Production
Graphic Designer	Digital Production
Technical Support	IT Infrastructure
Programmer	IT Infrastructure

We discuss the training program in section 2.3.

2.2 Maturity Strategy

E-Learning planning can be divided in three levels: Macro planning, concerning organizational wide change, Middle planning, concerning education programs development and Micro planning, which concerns specific on-line course planning. We talk about macro planning in this section.

The majority of e-learning projects will take an already existing organization and move it to IT. This implies major organizational changes that must be made step by step. We call this process the Capability, Ability and Efficiency Maturity Strategy (CAEMS), which is a five step program for organizational change. We present it here as a specific e-learning strategy, but in fact, can be applied to any IT project. The five steps are as follows:

1. **Awareness**. Establish the need for change. Motivate people to participate. Clear all concerns and establish what will be gained.
2. **Governance and compromise**. Identify a knowledge and process administrator body and establish written compromises of all those involved.
3. **Planning and prerequisites**. Plan organizational change, secure all resources and establish performance measures for all three supports.
    i. **Technology->Capabilities**. Establish IT architecture to integrate e-learning to all organizational components.
    ii. **Training->Abilities**. Establish a comprehensive training program.
    iii. **Process->Efficiency**. Establish and educational model. Determine best teaching techniques.
4. **Programs and applications**. Establish target audiences. Develop cohesive academic programs. Deploy e-learning tools.
5. **Knowledge administration**. Document organizational change. Manage relations with students and teachers. Make the process repeatable.

2.3 Human Resource

Human resource formation must be oriented towards competency. That is, clear profiles of jobs description and professional abilities must be determined, while at the same time providing enough flexibility to allow change and innovation. Competencies can be demonstrated by professional certification. We suggest as much in Table 2.

Table 2. Work responsibilities and professional certifications

Responsibility Area	Professional Certification
Finance and administration	• ISO-9000 • 6 Sigma
Instructional design	• Internal program
Digital production	• CMMi • Macromedia • Adobe
IT Infrastructure	• EIA/TIA 568b,569 y 566 • CSIP • CCNA y CCNP • Linux y Windows Server • SUN Java • Microsoft developer

As the finance and administration area competencies are no different than in any other organization, we propose the following minimum training program for the other areas in e-learning organizations:

Table 3. Training program for e-learning projects

Responsibility Area	Curse	Modality (Format)	Length (hrs)
Instructional Design	Sensibilization y Educational Model	Traditional	8
	Learning Platform Use	Traditional	8
	On-line Learning (Didactic Techniques)	Traditional	8
	On-line Course Design	Traditional	8
	On-line Tutoring	Traditional	8
	On-line Teaching Workshop	On-line	120
	On-line Course Design Workshop	On-line	120
	Advances On-line Tutoring	On-line	40
Digital Production	Digital Production Workshop	Traditional	40
IT Infrastructure	LMS Administration Workshop	Traditional	40
	LAMP and LAPP Environments Integration and Programming	Traditional	40

2.4 IT Capacity Planning

As already mentioned before, there are no proven IT capacity-planning mathematical models, such as the Erlang model, which is very accurate for telephony projects. It is not that models have not been proposed. In fact the problem is that there are too many models and it is hard to choose one. At E-LANE, we have been working on mathematical models that seem to make very good predictions on specific platforms and environments.

These models rely on careful performance measures taken from the demonstration projects and proven assumptions about performance behavior under differing conditions. Also, questions of seasonality, such as assignment deadlines must be taken into consideration. For example, Table 4 shows how many times the normal load can be supported as a function of the number of deployed servers, with only 5% of server saturation probability. This table describes the capacity planning for the Regional Institute of Public Administration, in Nuevo Leon, Mexico.

Table 4. Load increase acceptable as a function of the number of servers

Number of Servers	Overload probability (normal load)	Load increase that would exceed 5% overload prob
1	0.10138%	2.2
2	0.00153%	4.3
3	0.00011%	6.5
4	0	8.6

This model was developed by determining that a response delay by the server of over 3 seconds was unacceptable and determining with such a limit, based on normal load samples of installed LMS environments, how many requests could be served concurrently. Although this model is basically a simple Poisson model, other models based on chaos theory are being developed and tested. We hope they will achieve greater accuracy.

2.5 Cost Model

The cost model was developed by classify costs into two types of fixed costs: acquisition and training, and two types of recurring costs: operation and maintenance. This is not unlike Gartner's Total Cost of Ownership model (TCO) [6], except that since we suppose no previous IT downtime costs and lost opportunity cost were left out. Table 5 shows cost model details along with the actual values form Nuevo Leon's Public Administration Center.

In this cost analysis, part replacement is included in depreciation of equipment which must be substituted every four years. Indirect costs were computed as 20% direct costs, while structured cabling was computed as 10% total networking budget. Salaries were computed using the regional government's own transparency web page, while the rest of the costs were computed at current market prices including taxes.

3. CONCLUSION

We have thus provided for many up and going e-learning projects something that many of them did not have before: a list of risk factors and best practices, a maturity strategy, capacity planning tools for human resources as much as technology resources, and a cost model that enables economic analysis. All these tools will enable e-learning projects to understand true needed effort and resources and to achieve long-term sustainability prolonging project's influence on society long after project budgets have dried up.

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Table 5. Cost model details

Cost Type	***Details***		
Acquisition	Hardware	• Servers: USD$24,000 (8 x USD$3,000) • Internet router: USD$2,000 • Switches: USD$7,240 (2 x 48 ports USD $3,500) • Workstations: USD$75,000 (50 x USD$1,500 c/u)	
	Software	• Load balancing: $0.00 Linux Virtual Server • Mirroring: $0.00 DRDB • High availability: $0.00 Heartbeat • DB Cluster $0.00 NDB-MySQL • Other $0.00 (LAMP, dotLRN, Moodle)	
	Network	• Cabling: USD $10,800 • Link: USD$5,808 (1,024 kbps)	
	Salaries	• Planning: USD$9,000 (1 person, 90 hrs, USD$100/hr) • Coordination: USD$9,0000 (1 person, 90 hrs, USD$100/hr) • Installation: USD$20,000 (2 people, 20 hrs, USD$50/hr) • Integration: USD$20,000 (2 people, 20 hrs, USD$50/hr)	
Operation	Network	$4,406/mes (enlace a 1,024 mbps)[5]	
	Other	?	
	Salaries	Administrative	USD$5,440/month (2 people)
		Developers	USD$5,440/month (2 people)
		Instructors Tutors	USD$5,440/month (2 people) USD$30,600/month (20 people)
		IT Administrators	USD$5,440/month (2 people)
Maintenance	Salaries	Programmers	USD$5,440/month (2 people)
		IT Administrators	Same as before
	Software licenses	USD$0.0	
	Replacement / Depreciation	USD$2,075/mes[9]	
Training	Instructors	USD$6,000 (40 hrs)	
	Tutors	USD$2,000 (20 hrs)	
	Admin TI	USD$2,000 (20 hrs)	
	Developers	USD$2,000 (20 hrs)	
	Programmers	USD$2,000 (20 hrs)	
Indirect	20% direct costs	• Acquisition/Training: USD$31,696 • Operation/Maintenance: USD$11,403/mes	

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